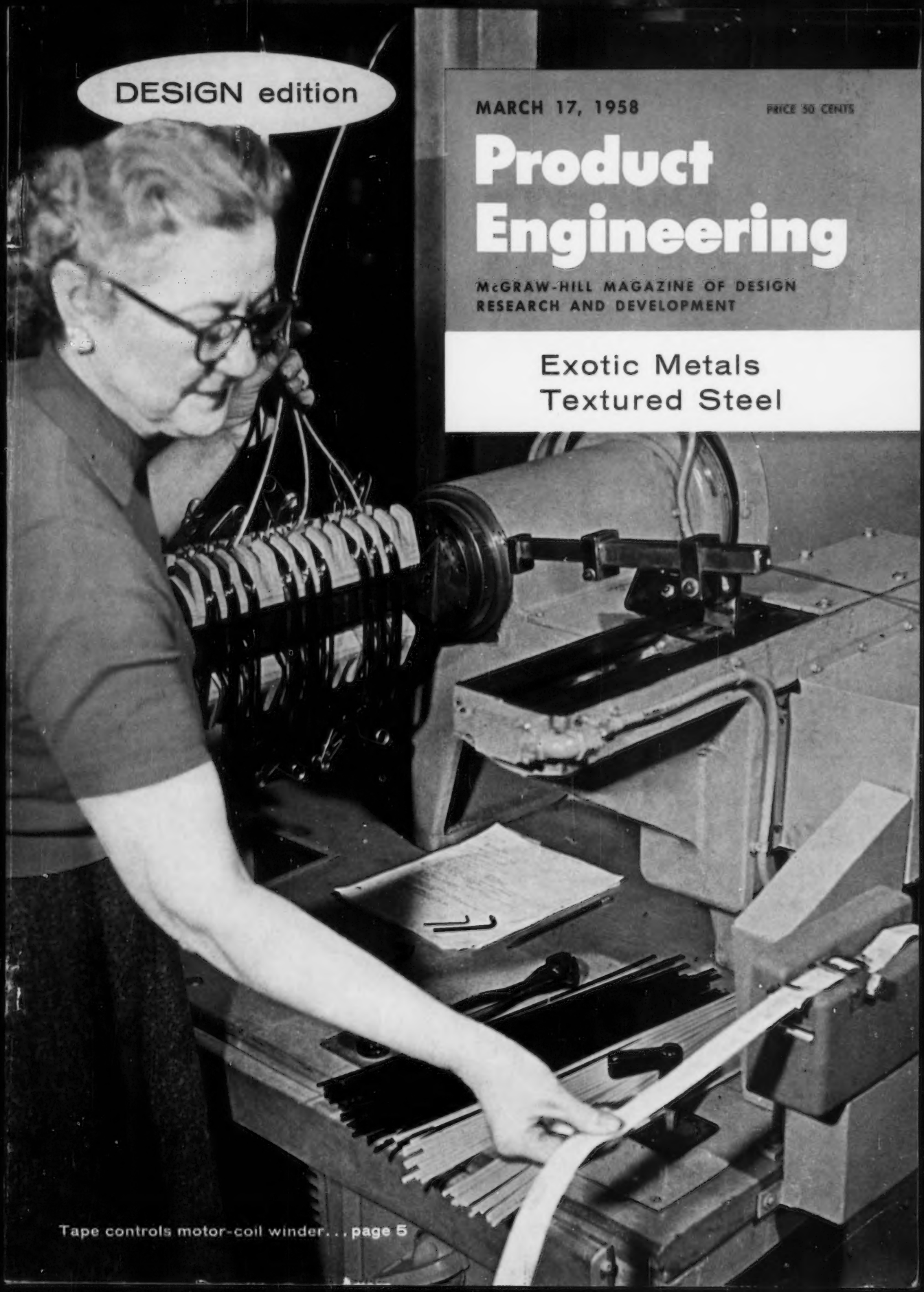


DESIGN edition

MARCH 17, 1958

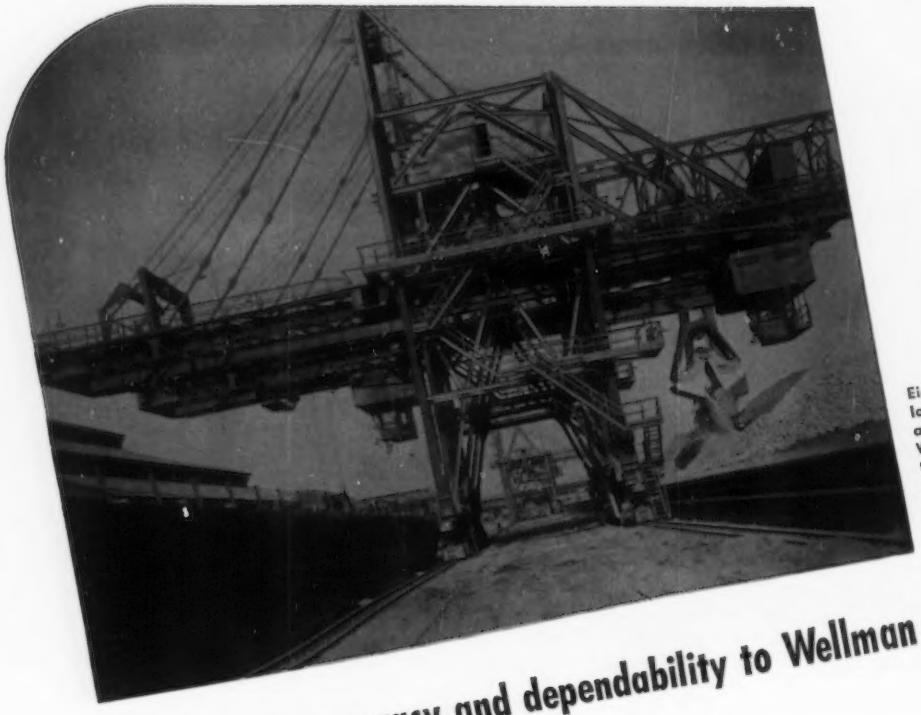
PRICE 50 CENTS

Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN
RESEARCH AND DEVELOPMENT

Exotic Metals
Textured Steel

Tape controls motor-coil winder... page 5



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Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

MARCH 17, 1958 Vol. 29, No. 11

SPECIAL REPORT

Exotic Metals Seek Employment *66... Annesta R. Gardner, Associate Editor
Common labor is for common metals. But for special structural and electrical problems, consider the more or less "rare" metals. Here are nine helpful ones ready to be put to work.

Maintenance Advice for Fluid Circuits 71... John Pippenger, Double-A Products; R. M. Koff, Associate Editor
This checklist covers the principles—preventive and troubleshooting—that will keep hydraulic equipment working properly.

IN FULL COLOR

Textured Steel *73... Ford R. Park, Associate Editor
Here is a low-cost alternative to expensive, major redesign—with materials offering eye appeal and functional advantages. Article covers texturing methods, design know-how and trends, and two new processes for turning out textured steels in showy colors.

Which Adhesive for What *79... R. W. James and R. W. Gormly, Arthur D. Little, Inc.
Today's adhesives are many and develop terrific strengths—if applied correctly. This guide includes a fast-reference table.

Design Features in New Products 82... Scale computes weight correction; tape controls multifunction drill; truck goes into 4-wheel drive automatically; grinder's supports reduce vibration.

Glass-ceramics Go Commercial 87... Dr. J. H. Munier, Corning Glass Works
This week Corning announced commercial production, in 2 grades, of the materials called Pyroceram. Experimental applications include ball bearings and pistons. Here are working data.

Input-output Analysis of Mechanisms 90... J. O. Predale, Newark College of Engineering
The principle of virtual work is applied to four-bar linkages, giving rapid, accurate answers to problems involving dynamic torque ratios. With diagrams and sample problems, the author shows how.

DESIGN FILE

17 Wedge-action Assemblies 96... Federico Strasser
A roundup of how-tos for both temporary and semipermanent assemblies held only by friction.

Shock Factors for Impact Loads 99... G. H. Howell, Wayne State University
There's a knack to proper design—under impact, weaker supports may excel stronger ones. Charts show what factors apply.

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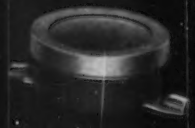

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Interesting to Note . . .

As the Trains Go Rolling By

Ever been caught at a railroad crossing when a parade of freight cars rolls past? If you've ever counted the number of different railroads represented on that one never-ending string of cars you could discover that in this country there are 181 operating lines. One of these roads, the Southern Pacific, has the problem of governing the movement of more than 10,000 empty boxcars. Each car on its lines that belongs to another railroad costs the Southern Pacific $2.75 a day. To analyze and simplify its routing operations, the company has recently employed computers and data-processing equipment. Another way to control the operations is with tape.

Tape control, a laboratory curiosity just a few years ago, is being more and more broadly applied. Our cover shows a tape-controlled coil winder at Schenectady in the new GE facility for making 40 to 125-hp motors. The tape at right controls number of turns, removing the human factor. Another application in the same plant, not yet perfected, is a control for a turret drill. The machine is built up from a Burgmaster turret and a positioning table, and the tape will select turret index to match a given table position. This removes the factor of human error in drilling and tapping motor end shields.

What's in a Name?

Naming a metal is usually left to the discretion of the discoverer. However, this isn't always satisfactory. In 1801, the English chemist Charles Hatchett was examining some minerals in the British Museum. In one dark rock, from the Connecticut River valley, he came across a new element and named it columbium. Several years later, Swedish chemist Dr. A. G. Ekeberg found a second element in the same dark mineral and called it tantalum because he came so near, yet could not separate the second element from the first.

A German, Heinrich Rose, rediscovered the first element in 1844 and named it niobium (for Niobe, the sister of Tantalus). Europeans accepted the name niobium while the American continued to call it columbium. Very little came of this controversy until several years ago when the International Union of Chemistry met in Paris. The group decided to rename some of the elements. Among other things, tungsten became wolfram and columbium

(Continued on page 7)

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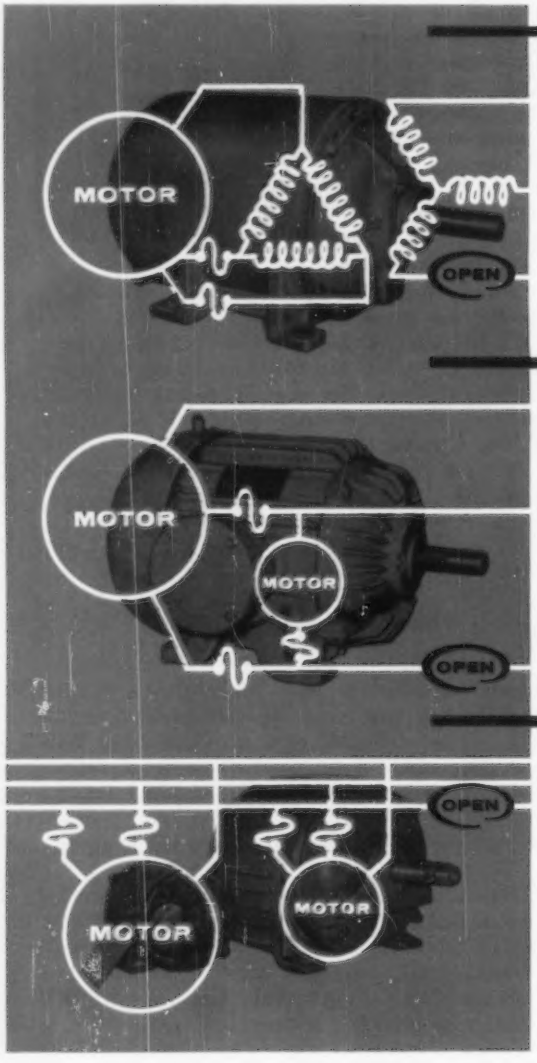
Three-Coil Overload Protection Would Have Prevented These Motor Burn-outs

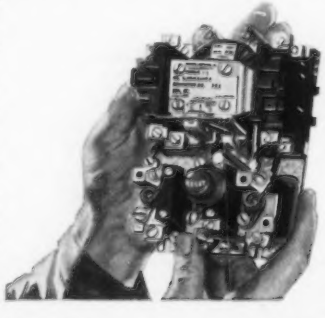


MOTOR No. 1. Even though this three-phase motor was equipped with a 2-coil overload relay, the motor burned out . . . and here's why. Like the vast majority of three-phase motors in use today, this motor took its power from a wye-delta transformer; and an open phase condition in the transformer primary caused one high and two low motor currents. The 2-coil overload relay could not save this motor because the high current was in the unprotected line. Why gamble with a motor burn-out? Insist upon 3-coil overload relays for all your three-phase motors . . . the only dependable overload protection for all open phase conditions.

MOTOR No. 2. This three-phase motor was operating at 70% full load with a 40% loaded single phase motor connected in parallel when one of the incoming power lines opened. Once again the 2-coil overload relay failed to detect any trouble. However the motor current in the winding without a thermal element rose to 152% full load current, while the current in the phases with the 2-element relay did not reach tripping value. This caused permanent damage to the motor winding. This motor could have been saved with full three-phase overload protection. Be sure your three-phase motors are completely protected from the hazards of all open phase conditions with dependable 3-coil overload relays.

MOTOR No. 3. This 1 Hp, three-phase motor was working in parallel with a 10 Hp, three-phase motor when one of the incoming power lines opened. While the 10 Hp motor was not adversely affected by this circuit unbalance, the motor current in one line of the 1 Hp motor reached 140% full load current resulting in a burned out winding. As in the other examples, the 1 Hp motor's 2-coil overload relay proved ineffective because the overload occurred in the one line left unprotected. Don't let this happen to your motors. Insist upon 3-coil overload relays for every three-phase motor, large or small . . . only 3-coil overload relays provide dependable open phase protection under all operating conditions.

Cutler-Hammer Three-Star Motor Control offers 3-coil overload relays in all standard starter constructions and enclosures. For immediate delivery see your nearby Authorized Cutler-Hammer Distributor. Machine designers and panelbuilders, open type Cutler-Hammer Three-Star Motor Control with 3-coil overload relays require no more space than starters with only 2-coil overload relays. CUTLER-HAMMER Inc., 1332 St. Paul Ave., Milwaukee 1, Wis., *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.



CUTLER-HAMMER
MOTOR CONTROL
C-H

Interesting to Note . . . . *(continued)*

became niobium. American chemists objected. "If Hatchett found the element in an American mineral and wanted to call it columbium, why change it?" Next time the International Union met, it repealed the tungsten-wolfram change, but stood pat on niobium. Today there is confusion. The American Chemical Society favors niobium while most others have swung to columbium. In the article on page 66 we stick with columbium. However, if you're used to niobium, go right ahead and fear not either odium or opprobrium.

Early Weights

On a recent television interview, a noted physicist explained that one of the purposes for landing on the moon was to learn more about the earth. He said we could establish a more accurate estimate of the earth's weight. How to go about this was not explained.

The problem of weighing an object, be it the earth or a microbe, has been with man a long, long time. The first scales were the weights and balances, dating about 2500 B.C., in the pre-Aryan civilization of northern India. These were used by goldsmiths, jewelers and temple priests to weigh gold dust. Most of these weights were highly polished stone. This was fortunate because later-period bronze weights have been less durable.

In early days, each nation devised its own standard of weights. These usually were in the form of polished blocks of hard stone or carved figures like the "resting

Early Weight Standards

Courtesy of the Metropolitan Museum of Art

Resting Duck—800 B.C. **Boar's Head—2000 B.C.**

duck" of the Assyrians or the "boar's head" of Mesopotamia. Wherever these early weights have been uncarthed, close by were some artifacts of gold.

In the corner of an old pharmacy today may still be found a balance not too unlike the first balances found in ancient Egypt. But time marches on. An innovation in scales is described on page 82—instead of giving weights, it gives weight corrections to be made.

It Paid to Be Stuck

As every designer, builder or do-it-yourself addict knows, attaching one object to another cannot always be done with versatile Scotch tape. Ages ago, before adhesives like those described on page 79 came into being, man resorted to a form of glue to stick two objects together. Stone carvings and furniture, more than 30 centuries old, have been removed from tombs and show that the Egyptians knew how to prepare and use animal glue. Today when there's an adherence problem the first thought of many folks is "Where's the Scotch tape?" How the Minnesota Mining and Manufacturing Co. developed this transparent tape is a story that shows how trying to solve one problem can solve another.

The Flaxlinum Co., selling housing insulation in 1929, had an order for material to insulate several hundred railroad refrigerator cars. The company found its regular material developed an unbearable odor when it came in contact with moisture. Flaxlinum wanted a waterproof tape to seal the slabs of insulation. It took the problem to 3M, where Dick Drew started researching. He ran into one difficulty after another. If he found a moistureproof adhesive, the paper would deteriorate; a moistureproof paper wouldn't take an adhesive.

By coincidence, the lab adjoining Drew's was experimenting with a new Du Pont moistureproof cellophane to wrap a masking tape invented by Drew himself. When a 3M chemist showed a sheet of the new cellophane to Drew, Scotch tape was born. An adhesive was soon found to hold the cellophane to just about any surface. Scotch tape has since turned out to be the company's most famous product.

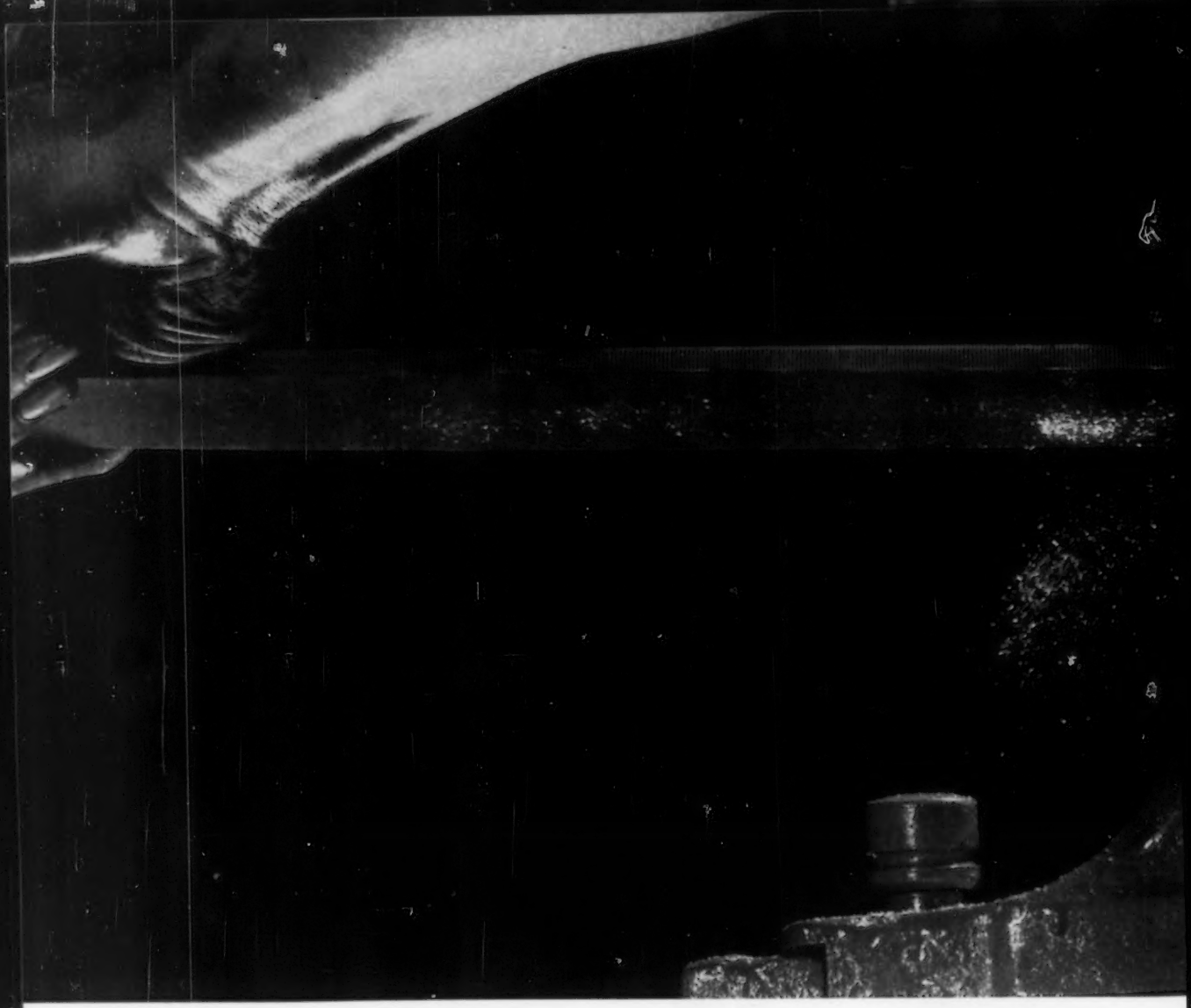
A Twist of Steel

By working his way west from his New Hampshire home, young Joseph Glidden was able to earn enough money to purchase 600 acres of farmland outside De Kalb, Ill. He worked hard, and by turning his profits into additional acreage, he soon acquired 1500 acres plus a herd of cattle. Like all cattlemen of the 1860's he found it hard to keep livestock on a closed range. Wooden fences were hard to erect and easily broken. In 1873, Glidden attended a county fair in De Kalb and noticed a crude barbed wire fence invented by Henry Rose. He liked the idea but thought he could do it better. With a coffee grinder to make barbs and an old grindstone to bend wire, Glidden devised the first practical barbed wire fence.

He received a patent in 1874 and decided to offer half interest to a neighbor for $100. The neighbor wasn't interested, but Isaac Ellwood, a local hardware merchant, could read the future and paid $265 for that same half interest. The Barb Fence Co. was formed and sold within two years for $60,000 plus royalties which brought in close to a million.

Barbed wire, a new twist to common steel wire, actually changed the future of America's meat industry. In 1956, over 70 tons of this wire was produced to fence in livestock. Steel continues to find important new uses in engineered products as new forms are developed. Sheets with textured surfaces, page 73, offer new methods to improve appearance and reduce cost.

—Benedict A. Leerburger Jr.



Wear Resistance is a common problem for designers, even when they're using a durable material like steel. Of course, it is well known that you can increase the abrasion resistance of a given steel when you improve its hardness (and thus, its strength). But when you harden and strengthen a steel so that it will resist wear, you usually run into some complications.

For instance, when we vary the wear resistance of steel, we also vary its *other* properties, and this causes problems for the designer or his metallurgical adviser. Examples: hardness and strength can be developed in various ways—increase the carbon content, add alloying elements, cold work, heat treat. These methods vary in cost, and each has a different effect on hardness, strength, toughness, corrosion resistance, formability and weldability.

There is one steel with the best combination of properties for every design application, and you're almost sure to find it in the vast range of USS Design Steels—whether Carbon, High Strength, Alloy or Stainless Steel. Here is the widest range of steels available, offered by a company that has produced well over a *billion* tons of steel.

Of course, over-design must be avoided as rigorously as under-design, and designers must always walk the prickly path between poor product performance on one hand and high costs on the other. Somewhere among the many USS Design Steels there is the one best steel for the job. The final selection can best be made with the help of a skilled metallurgist—either on your staff or ours.

USS **United States Steel**

STEELS FOR DESIGN

Lower Left—Problem: Blades on this earth dammer wore out after 300 acres. Solution: Blades are now made from USS MAN-TEN Steel, one of several USS HIGH STRENGTH STEELS. Benefit: Blades now last over 1,000 acres for Gunning Mfg. Co., Lansford, N. D.

Lower Middle—Problem. The new "Snow Hawg" rotary snow plow chews into ice, rock and frozen earth and throws it up to 300 feet. A weldable, very strong steel was needed to withstand the punishment. Solution: Vital parts are made from USS "T-1" Constructional Alloy Steel. It can be field-welded, and remains strong and tough down to minus 50°F. Benefit: Outstanding performance, and chute liners of the "Snow Hawg" last two to three times longer.

Lower Right—Problem: Chutes in a coal processing plant wore out prematurely due to abrasive action of coal and corrosion from acid water. Solution: Chutes made from USS Stainless Steel were installed. Benefit: New chutes outlast old ones seven to one. Atkins Coal Company, Frackville, Pa., estimates that a $900 investment in Stainless Steel chutes saved $30,000.

USS, MAN-TEN and "T-1" are registered trademarks of United States Steel

You don't have to be over 21

to install and maintain

a Fenwal temperature indicating controller

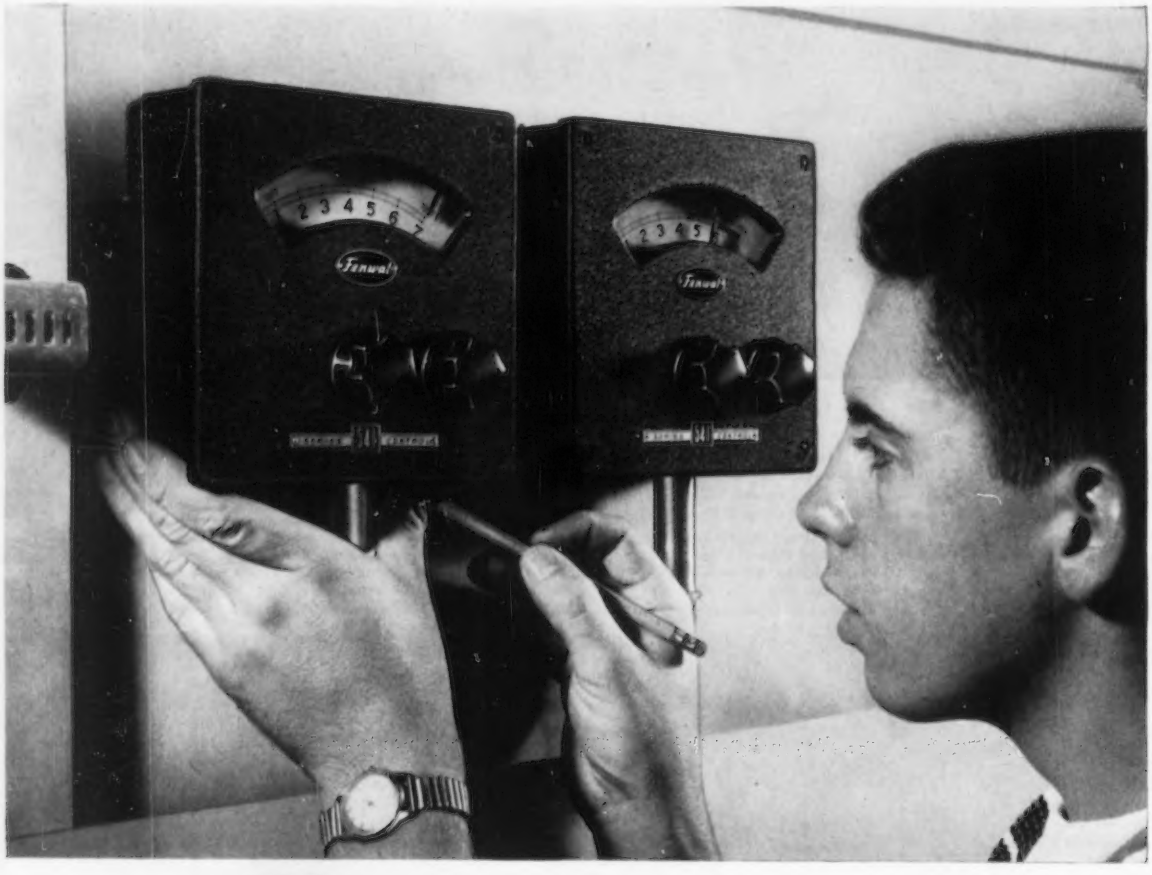
It really is a cinch for an untrained person to install and maintain Fenwal's 541 Temperature Indicator Controller. You don't even have to open the case to adjust it — even its snap switches can be easily replaced without disturbing the internal mechanism. *It's simple!*

In Fenwal's 541 all moving parts are in opposition — wear on one is automatically compensated for and the controller's high accuracy remains unchanged! *It's reliable!*

You can take your choice of temperature range, bulb styles, and one or two circuit controls, current ratings — even the color of the housing. There are literally hundreds of adaptations that can be made from stock! So you get a tailor-made, fit-to-order controller at a competitive price! *It's versatile!*

Drop us a line at Fenwal Incorporated, 23 Pleasant Street, Ashland, Mass. and we'll send you our catalog MC-139 or our sales engineer, whichever you want.

This is our dual circuit model (we've got hundreds of others) which has two snap switches, each with a set point indicator, that actuates two circuits at pre-set temperatures. Housing in all Fenwal 541's meet NEMA and JIC specifications.



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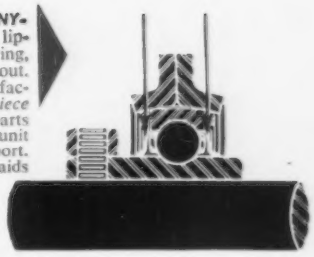
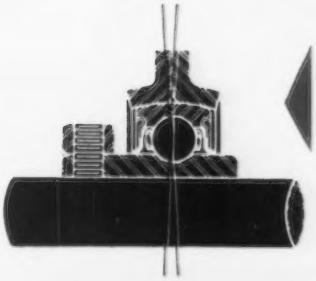


LINK-BELT JPS-200 ball bearings maintain capacity despite shaft and support deflection

IN rugged field service, supporting structures on farm machinery and similar equipment undergo inevitable weaving. Shafts, too, are subject to dynamic deflections. Answer: *self-alignment* — the ability of Link-Belt bearings to adjust under these conditions. And it's yours *at low cost* in this precision Link-Belt ball bearing.

Equally important, Series JPS-200 bearings achieve their economy with *no loss of efficiency*. They combine sturdy pressed-steel housings with standard, full-capacity Link-Belt ball bearings.

Folder 2517 has complete data on the Link-Belt JPS bearing series, and Book 2550 covers the entire Link-Belt bearing line. Get both from any of 40 Link-Belt offices.



FREE ROLLING AND FULL LOAD CAPACITY are maintained even under shaft or support misalignment with Link-Belt self-aligning feature. Extra-long inner ring of bearing assures proper load distribution. Heavy spring-locking collar firmly secures bearing on shaft.

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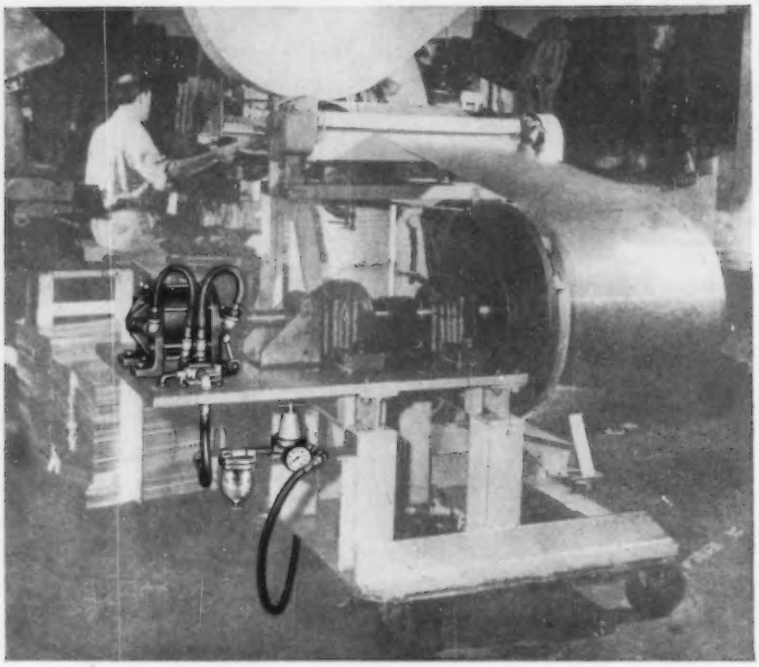
YOU CAN TAILOR AIR CONTROL UNITS FOR ANY JOB WITH STANDARD SCHRADER PRODUCTS

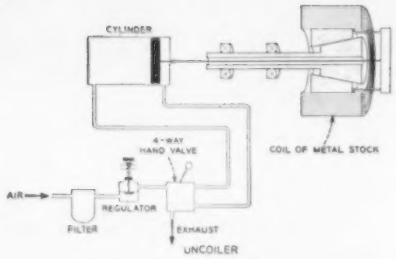


Every day more designers, more engineers are solving problems with air. They're planning air systems to hold, clamp, move, trip, feed, eject . . . from tiny parts to 3000-pound coils.

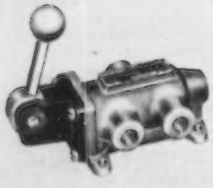
Air is versatile, economical, safe, fast. And when you select your components from Schrader, you choose from the most complete line of air products. Whenever you mechanize manual operations, or automate mechanized ones, investigate air. Schrader engineers are prepared to help you like we did here.

HERE'S AN INTERESTING SHOP PROBLEM SOLVED BY SCHRADER: How to strip steel from 3000-pound coils:

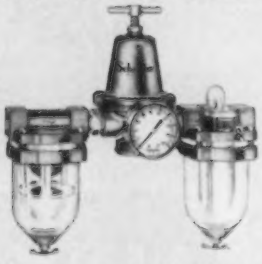
Radial jaws actuated by a Schrader air cylinder hold the coil firmly on an expanding mandrel. A 4-way valve and a pressure regulator govern the air power. Wherever uncoiler is needed it is plugged into an air line with quick-acting couplers. Opening the 4-way valve actuates the cylinder and the operator works freely at this machine. Just imagine the time and trouble, this one idea saves this company! Here's the hook-up



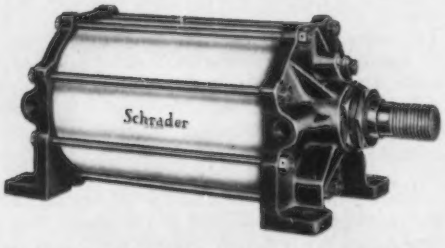
HERE ARE SOME OF THE SCHRADER PRODUCTS SELECTED FROM THE HUNDREDS OF SIZES AND TYPES:



Four-Way Hand Valve operates through a simple hand lever. Can also be operated automatically or with pedal.



Lub-air-ator: special 3-part unit that lubricates, regulates, filters air line. Easily adjusts pressure.



Double Acting Cylinder: is used here for its powerful two-direction stroke. For one way powered stroke, use single acting cylinder with integral spring return stroke.

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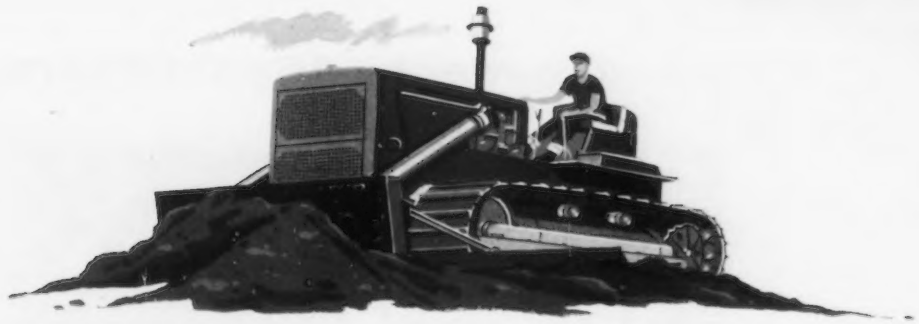
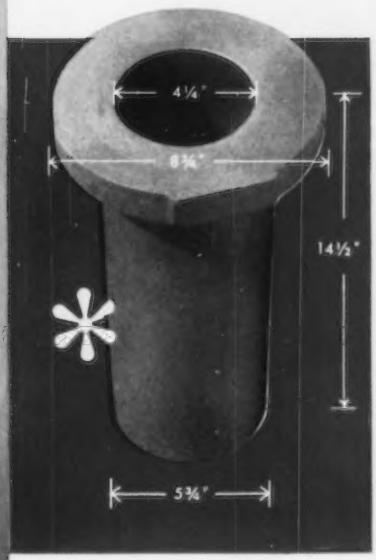


FORGINGS for one machine



Sounds fantastic doesn't it? Yet, we have been producing forgings for leading equipment manufacturers for 2½ decades. They depend on AmForge to provide the forging facilities and engineering they need. Continuous, uninterrupted on-the-job service is the most important requirement of a machine. Forgings provide this dependability. We invite you to use our research engineering and production know-how for your development work.

✻ *This rear axle housing for a tractor is interesting because it is forged from tubing stock. AmForge engineers determined that this method would save weight and material since no finishing or drilling would be required internally.*

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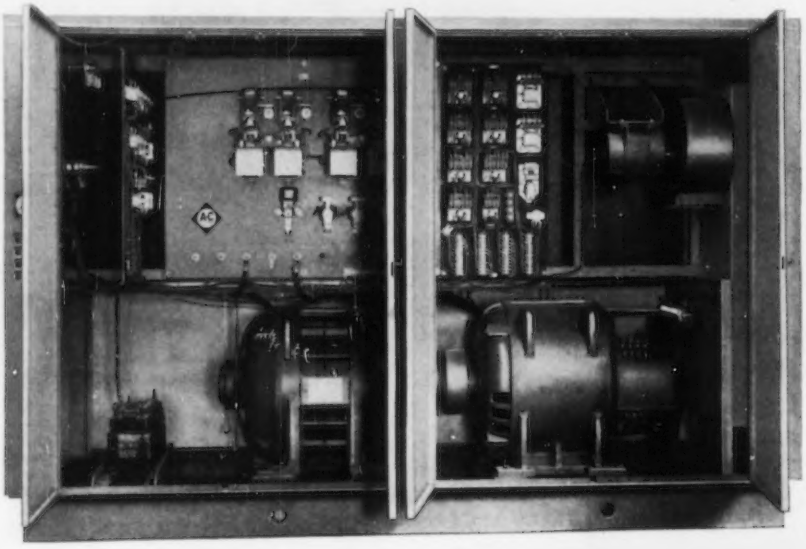
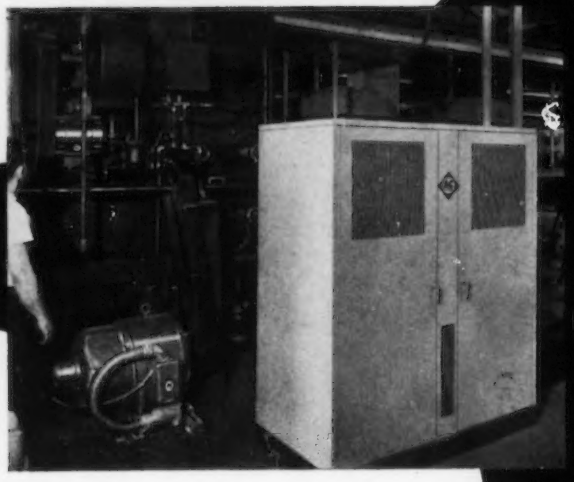


Size 5 *Ultra-Speed* power unit, rated 125 hp, providing reversing and regenerative braking.

Ultra-Speed power unit assures smooth, selective speed control for offset printing press.



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Ultra-Speed — remember it! It's a name you'll be hearing more and more. It identifies Allis-Chalmers variable-speed package drive — the complete power conversion unit featuring wide speed range and continuity of operation.

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DEVELOPMENTS TO WATCH...

Anodized aluminum magnet wire . . .

. . . at a price competitive with enameled copper, is on the way. Anodized aluminum wire (0.001 to 0.025) and strip (down to 0.001 or 0.003) are not in themselves new. They've been produced in the US and Britain for 15 years; but they've been a premium product; and, in some cases at least, the anodic coating has not been comparable to enamel in insulating value. Also, the anodic coating tended to be hygroscopic, so that dielectric constant was adversely affected by atmospheric moisture.

Now though, operating temperatures of transformers, relays, and instrument coils are going up—and the enameled product can't stand the heat, so demand for a satisfactory anodized material is increasing.

That makes a British claim hot news indeed. It's said that a new production process will turn out anodized aluminum wire for service at temperatures to 600 F that can be sold at a competitive price. At the same time, US and Canadian producers, spurred by this report, are working hard to match these claims, and expect soon to announce improved, lower-cost processing techniques.

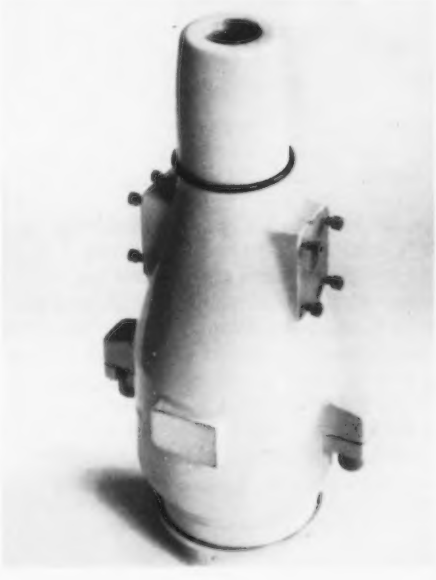
Unforeseen fire hazards . . .

. . . can crop up in almost any product, despite normal design precautions. Automatic dryers are a case in point. If the housewife cleans the lint collector in her automatic dryer regularly, as she should, there should be no trouble. But housewives don't always read instructions, much less follow them. So, lint collectors are becoming a factor to reckon with in household fires. Worried fire-insurance companies and organizations are collecting data, encouraging re-examination of product design, hoping this situation will serve as a stimulus for greater precautions.

Half a dozen new instruments . . .

. . . for systems using radioactive isotopes to detect flaws, measure thickness, and locate radioactive products, will be displayed by Isotope Developments, Ltd. Beenham Grange, England, at the Physical Society Exhibition in Westminster at the end of this month. One instrument, the scintillation counter head pictured here, is available with a built-in amplifier to suit existing scalers and rate-meters, or with a direct output. Another is an inspection device for "firewire" (the fire-detection lines used in aircraft). This "wire" consists of a stainless-steel tube surrounding a glass-insulated Nichrome core. The instrument, which is a beta-ray transmission device, is designed to uncover discontinuities in the glass by registering an increase in the amount of radiation transmitted.

Also to be displayed is a beta-ray thickness gage for turbine blades, and a potentiometer unit that permits operation of two scintillation counters or Geiger-Mueller tubes from the same supply unit.



Scintillation counter head is shielded in all directions, can be fitted with a variety of collimators.

DEVELOPMENTS TO WATCH...

Use weaker materials . . .

. . . to bypass metal fatigue? That's one solution. But a more effective way, suggests C. R. Smith of Convair, is redesign. Though there are conditions under which a weaker alloy will show superior fatigue properties, the principal gain in fatigue life where such alloys are used comes because their low static strength makes fatigue-free design inescapable. Why not, then, start out with the stronger alloy and learn how to design for it, he asks.

For instance, it is known that fatigue life can be increased by prestressing. To take advantage of this fact in riveted airframe joints, Convair is thinning down the understructure, and adopting a rule of thumb that "where the first row of rivets engages a splice, the understructure can never be more than half the thickness of the part being spliced" (except on very thin skins). This is, Smith admits, a radical departure from the notion that the bearing strength, sheet tearout, and tension area have to develop the full rivet strength. But, he says, it permits use of the stronger 75S (7075) aluminum in place of 24S (2025). Laminated joints, arranged so the first row of rivets engages only a single laminate, have lives 10 times those of traditionally designed joints.

Trend to solid electrolyte capacitors . . .

. . . is highlighted by an Aries Associates report that notes production of tantalum capacitors of this type has more than doubled in the past two years, is expected to double again this year. (1956 production was 350,000; 1957 800,000; estimate for 1958, 2 million).

Miniaturization and increasing use of transistor circuits are pushing development of tantalum capacitors, says Aries, and interest is as high in Western Europe as it is here. The reasons:

Solid electrolyte tantalum capacitors can not leak or corrode. They are small and compact, may be used over a temperature range of −100 to +250 F, and at potentials as high as 50 v. Several types are made, using a number of methods for preparing the thin oxide layer that serves as the dielectric.

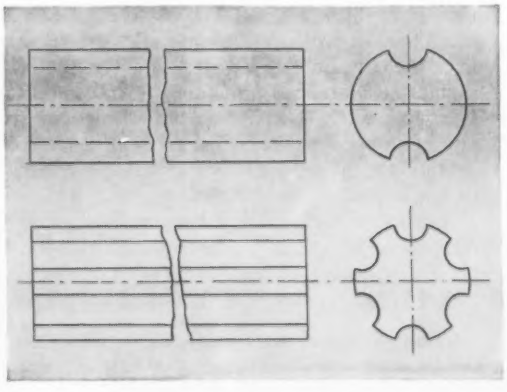
Use of tantalum resistors and rectifiers is also on the rise as the useful electrical properties of this metal, best known for its corrosion resistance, gain recognition. At room temperature, its electrical resistance is 3 times that of tungsten (electrical resistivity at room temperature is 12.4 microhm-cm).

Metropolitan transportation will be . . .

. . . the next multibillion-dollar market, predicts K. M. Hoover of GE. New ideas in mass transportation, he says, are long overdue. The scope of the problem, and the need for a coordinated effort to solve it, are highlighted in a new movie, "Millions on the Move," available from GE sales offices.

Weld-filled bolts . . .

. . . are being tested by Gebr. Boehler & Co., A.G. of Vienna for applications requiring high tensile and torsional strength and resistance to wear. Manganese steel, or some other high-hardness alloy, grooved as shown in the diagram (by rolling or flame-cutting), is the starting point. Then, the grooves are filled by weld metal, using a hard chrome-alloy rod. The method is designed to replace hard-surfaced bolts, which, the company says, were unsatisfactory because the thin, hard coating tended to separate from the base metal when the bolts were running hot. The new design is said to stand up well under pressure and frictional forces—even when lubrication is insufficient. —ARG



RANKS AND FILES:

Armed Forces to Mechanize Storage of Drawings

DAYTON, OHIO—The military services are mechanizing storage of their engineering drawings. The change, a fundamental one, will substitute microfilm, business machines, and automatic cameras and reproducers for paper, people and blueprints. The switch promises enormous economies.

An extensive R&D program has produced new data-storing equipment that, though tailored for the services, can be modified for nonmilitary applications. Out of the services' experience should come more sophisticated designs. These should spread mechanical storage still further—the microfilm principle is applicable to handling of nearly all records.

Microfilm-storage programs are now under development by the Army, Navy and Air Force. The services were forced to make a radical change because engineering drawings were gobbling up floor space at an alarming rate. The experience of Wright Air Development Center, central depository for all Air Force equipment drawings, is typical. As type and complexity of military equipment have multiplied, WADC's central files have swelled to 3.5 million full-size drawings. New and revised drawings are arriving at the rate of 18,000 a week.

MORE AND MORE PROBLEMS

That's only half the problem. The Center must send copies of engineering drawings to outlying posts that need them. Reproductions are now made by the relatively expensive Vandyke and blueprint processes. Hence, the Center is responsible for a mammoth and costly storage and reproduction assignment.

In the streamlined system that will go into effect in about two years, the Air Force will require all suppliers submitting engineering drawings to send the drawings in on rolls of 35-mm microfilm. (About 3400 contractors are involved.) Along with the microfilm the suppliers will include a deck of code-punched tabulating-machine cards. At Wright Field, data-processing machines will punch the code on the suppliers card into an aperture card—a tabulating card with a window in one corner. The microfilm drawing that goes with the card will be mounted in the opening. Multiple copies of the tabulating card and microfilm will be made so that each Air Force facility with potential need for the drawing can have a file copy.

The microfilm drawings—both those retained at WADC and those sent away—will serve two functions: quick reference (through a viewer), and as on-the-site originals for reproduction (by an enlarger-printer). The reproduced drawing need be only half the size of the original because resolution of the microfilm is good enough to make the reproduction clear.

In evolving the new concept, the Air Force molded it around as much existing equipment as possible. But several new pieces were designed under development contracts. They include:

- A high-speed, electronically controlled microfilm camera to produce a roll of microfilm from a stack of drawings. The camera will convert the massive backlog of paper drawings now in WADC's files to microfilm. It can be programmed for all standard-size drawings and will maintain automatic focus for any reduction ratio. Electronic sensors compensate for differences in density of the drawing, and a built-in device stacks drawings after they are filmed.
- Equipment to mount films into windows of aperture tabulating cards. There are two versions of this machine. One is automatic and will mount 2000 drawings per min. The other is manual and will mount 100 to 125 per min. The manual machine includes a viewing screen so the operator can check the drawing against information on the punched card.
- Specialized film duplicator to produce multiple sets of microfilm. An operator can feed this machine positive or negative film on 100-ft rolls or mounted in aperture cards. The machine will turn out either a sequential record of the microfilm roll or up to 400 copies of each frame. It will blow up or reduce images, and place a maximum density bar between frames to act as a trigger on subsequent equipment. It also scans microfilm electronically to attain balanced illumination.
- Combination microfilm viewer and print enlarger to permit technical personnel to look at microfilmed drawings or get enlarged prints. The viewer is essential to every microfilm,

Battery of supporting equipment . . .
will help Air Force mechanize filing of engineering drawings at its Wright Air Development Center. Final specs have not yet been written but these items with possibly some additions and modification will be important links in the Air Force microfilm program. (1) Semiautomatic mounter by Filmsort Div., Dexter Folder Co., mounts microfilm on business cards; its screen permits operator to check microfilm against film data. (2) Automatic mounter by Filmsort mounts 2000 microfilms an hour. (3) Microfilm viewer and print enlarger by Cardo Corp. produces either an enlarged image of microfilm drawing for quick reference or an enlarged permanent print. (4) Microfilm enlarging printer by Haloid Co. makes quantity prints from microfilm drawings.

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hence it will be the most common piece of equipment in the system.

• High-speed microfilm enlarging printer to make quantity paper prints directly from film. The printer will assure the system's independence of blueprint machines. The 24-in. printer accepts aperture cards and automatically reprints microfilm images on paper at one-half to five-eighths original size. The operator can obtain either a sequence of drawings or multiples of a single drawing. Machine design includes devices to cut drawings from paper web, drop them into a stacker, and remove them from the printer so they can be tied and mailed. The machine has several advantages over its ancestor. It operates at four times the speed of a blueprint machine, and requires a single operator instead of four. It requires no sewage or water connections.

OFF-THE-SHELF EQUIPMENT

Other support equipment is off-the-shelf; the Air Force system is designed to incorporate several commercial units. Widely available punch-card and electrically operated filing cabinets are used. High-speed handling of large quantities of drawings is possible because of the electric oper-accounting machines now on the market.

The Air Force expects savings in labor, space and materials to outweigh the substantial R&D expenses. Microfilm files will use about 2% of the space occupied by full-size drawings. Filing and retrieving drawings will be carried out at automatic-tabulating speeds, taking only a fraction of the time needed by a file clerk. Microfilm drawings cost about one-tenth as much as full-size reproducables. Finally, shipping costs are lower. The Air Force estimates that microfilm drawings for an aircraft can be shipped in a cigar box. Full-size drawings would fill a boxcar.

Similar systems that differ in detail have been developed by the Army and Navy. Throughout the development phase, the services have exchanged information to avoid duplication. The Navy will install its system at Philadelphia, the Army at Ft. Monmouth.

Air Force spokesmen cite a number of reasons to support the view that microfilm storage is in its infancy. One is potential applicability of microfilm to a wide range of jobs. Specification and correspondence files could easily be committed to microfilm, as could bulletins and publications now stored in bulk and held for subsequent distribution. Further, military suppliers who must supply microfilms and punched cards to the services will very likely find it uneconomical to maintain both full-size and microfilm drawings. Cost cuts in labor, and floor space may be incentives to non-military suppliers.

The technology of engineering-data handling is entering an evolution speed-up. Designers are trying to introduce electronic storage and recall, and electronic transmission and print-back. Until now most of the work has been financed by the government, but private equipment manufacturers are sinking their own capital and facilities into development work. Improved designs and possibly some entirely new items to facilitate record storage are sure to sprout from this investment.

Other drawing-handling methods of interest to PE readers include recent developments by Keuffel & Esser Co., and Peerless Photo Products, Inc.

K&E's process, announced some months ago in PE, uses a 105-mm negative (4x6 in.) rather than the 35- or 50-mm negative employed in most systems. The negative can be blown up to a 36x54-in. drawing without distortion. One negative can hold up to eight 8½x11-in. drawings. K&E claims that the resultant drawings are as good as the original tracings in every case.

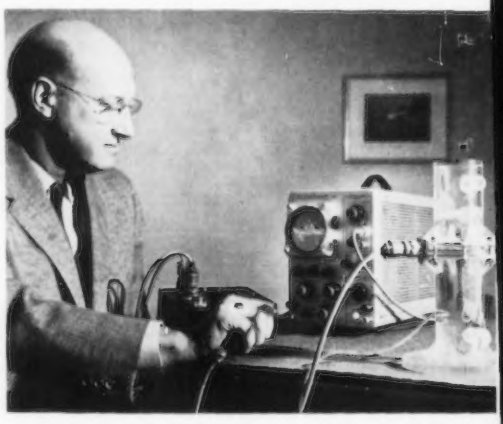
Peerless Photo developed what is now the Neoflow continuous reducing camera made by Pam Mfg. & Sales, Inc. The Neoflow camera puts negatives of engineering drawings on file cards. The reduced-size drawings read right and appear on glossy projection paper. In reproducing an existing engineering-drawing file, re-indexing is not necessary because the part-number identifications on the originals are reproduced. Six reduction ratios are possible with the camera: 6:1, 5:1, 4:1, 3:1, 2½:1 and 2:1.

Cavitation Detector Aids Research

PHOENIX, ARIZ.—A cavitation detector consisting of a sensing mechanism and controller developed by AiResearch Manufacturing Co. has important significance in rocketry, according to researchers. Cavitation in missile oxidizer systems can result in explosions when the oxidizer-fuel ratio has been upset. Cavitation occurs when pressure at any point in a fuel flow system approaches the vapor pressure of that fluid.

The detector determines any tendency of oxidizer and fuel systems to cavitate while undergoing development in the test stand prior to flight, or in flight, reports James Clark, AiResearch engineer in charge of the project. Gas detection by the unit has been extremely accurate, recording bubbles 1/20th-in. dia. in a 5-in. line. Detection signals are transmitted to an oscilloscope, a firing circuit such as a rocket booster ejection circuit, or a telemetering transmitter. Circuits can be calibrated for individual fluids, depending on characteristics of the liquid. AiResearch developers point to the unit as a research tool with applications for control of fluid flow in pumps and valves, as well as boiler feed pumps and distillate pumps in petroleum refining operations.

Bubble-tracer oscilloscope . . . undergoes test run which demonstrates recording of detection signals in rocket research project. Circuits can be calibrated for individual fluids, depending on liquid characteristics.



How Valuable Are Training Programs?

NEW YORK CITY—Business firms are fast becoming educational institutions, or at least financial backers of employe education. They find it's good recruiting bait, and that neophyte engineers need help bridging the gap between academic and industrial life. They also need encouragement to continue professional development. PRODUCT ENGINEERING queried several firms to check the impact of training programs on turnover and employe development. Here's what they say:

General Electric has evolved an elaborate training program for new engineers that is based on the company's 40 years of experience with education. New GE scientists and engineers are given rotating assignments in a few of the company's 100 product departments. Assignments last roughly four months. At the same time trainees have an opportunity to enroll in educational programs to prepare them for advanced engineering assignments. There are several of these programs at different levels of complexity. Successful completion of one course of study generally-qualifies a trainee for a more advanced program. A few employes selected for the honors program attend universities and earn a masters degree. The over-all setup is designed to give new employes a broad educational and practical experience in the company, so both the trainee and his supervisors can find out how he will best fit into the organization.

"It's difficult to measure the value of GE's educational endeavor," says M. W. Sims, director of engineering training and education, "but proof of our faith in it is the fact that we continued it through the depression years and war." Most of the GE trainees seem serious about making a career with the company, though, of course, some leave and apply their GE education elsewhere. (Present deans of engineering at Case Institute, Cal Tech and Carnegie Tech are alumni of GE training.)

One small Michigan company with a modest training program has discovered that educational help does not necessarily strengthen employe ties with the company. Case in point is the employe who got a leave of absence to get a masters degree at Michigan and wound up with both the degree and a faculty position.

Lockheed's Missile Systems Div., has sent 133 men for advanced schooling at Stanford and California. Participants work part-time, study part-time and collect regular full-time salaries. In addition the company pays the university directly for tuition, special fees and books. Lockheed believes the advanced-education program has been a decisive factor in reducing turnover. The company can't say precisely how much turnover has been slashed, but among those who participate in the program it's less than 1% a month. According to Lockheed, that's about half the turnover for the company as a whole.

Minneapolis-Honeywell grants tuition refunds for employes taking graduate courses. Last year 734 workers received assistance. M-H loses some employes, but finds it picks up about as many who have been trained in other companies.

Burroughs Corp. encourages its engineers to earn MA's and PhD's. They pay three quarters of the tuition and occasionally grant leaves of absence. Edward P. Case, public relations director, reports that a "minimum of 80% stay with the company after achieving advanced degrees and many of these are rewarded with salary increases and promotions as a result of advanced degree training."

Varian Associates participates in a cooperative honors program set up by Stanford and some business firms to permit students to work 35 hr and study 6 hr a week toward advanced degrees. Varian also pays partial tuition refunds, and last year inaugurated an advanced study program. Though the programs are relatively new, Varian thinks they helped hold turnover to 5% a year.

Stainless steel snout . . .
of US satellite Explorer undergoes final wall thickness check at The Lodge & Shipley Co., Cincinnati. Bullet-shaped nose cone, according to American Iron & Steel Institute's Committee of Stainless Steel Producers, is Type 430 stainless, same grade selected by automakers for car trim. Cone is 1 ft long, 6-in. wide at its maximum. Thickness of metal ranges from conical walls of 0.013/0.017 in. to 0.094 in. at the middle. Weight before assembly on the missile instrument package is 13 oz, unusually light for the strength of the shape. Cone has 16 equally spaced holes, 0.125 in. dia, drilled at its base for attachment to instrument package.

Bits and Pieces

Machine tools, electronic instruments and other capital equipment should be designed to harmonize with physical characteristics of human operators, says Henry Dreyfuss, industrial designer. Manufacturers could avoid costly errors if they tied proportion, texture and torque of knobs to statistical studies of human hands. . . . . The German firm Demag-Modag has developed a free-piston gas turbine rated at 2000 hp, 35% efficiency.

Retrieving Thorium

Recovery of thorium from irradiated slurry of the Pennsylvania Advanced Reactor will cost 1.12 mills per kw-hr. Add allowance for profit and federal income tax and cost rounds out of 2.4 mills per kw-hr. Cost figures were reported by two Union Carbide scientists to the 1958 nuclear congress. . . . . Yale geologist, Mead L. Jensen, has found that uranium usually turns up near concentrations of hydrogen-sulfide gas. Hence, painfully slow process of prospecting for uranium with geiger or scintillation counter may give way to more efficient laboratory techniques. Hydrogen-sulfide is generally found in oil rich regions, indicating, says Jensen, that uranium may be more plentiful than suspected.

Plating Progress Possible

Manufacturers could lick most pore problems in plating if they took adequate precautions, in the opinion of engineers at Wagner Bros., Detroit. Continuity of plate coating is more important than thickness, they say. If a part is buffed before it is coated, metal flows along surfaces and closes existing pores. This reduces base metal oxidation. . . . . "In periods of good times," says J. L. Wiggins of National Standard Parts Assn., "complacency and outright laziness lead many a small business man into financial traps. . . . . President Quigg Newton of Univ. of Colo. charges that 90% of the government's university research funds go to 12 private and 5 public colleges. Other schools should seek funds, he feels.

Emergency Gear Floats Whirlybird

MORTON, PENNA.—Emergency flotation gear that turns a helicopter into a seaplane during emergencies has been developed by Vertol Aircraft Corp. In flight tests at Philadelphia Navy Yard, a craft touching down at 30 knots taxied at up to 8 knots, and handled much like a conventional flying boat.

Key design features include sealed-fuselage construction and special floats of neoprene-coated nylon fabric. Floats on the main gear are drop-shaped to minimize drag. Forward float is attached to the fuselage by a girt strip that acts as fairing. Both floats, permanently inflated to 1.5 psi, are compartmented so the plane will float even if punctures are sustained in emergency landing. The fuselage is sealed to a 12-in. level above the static-water line. Total weight of the landing installation, including fuselage sealing, is 340 lb.

Engineers estimate that 80 lb of additional gear (air bottles, valves, etc.) is saved by keeping the bags inflated at all times. The flotation gear is expected to reduce cruising speed by only 4 to 5 knots.

Among advantages cited for the new system is avoidance of boatlike hull because of tandem-rotor configuration and long fuselage. Designers point out also that although the gear permits safe water landings, it is intended only as a precautionary measure. For regular operation from an aquatic base, additional hull compartmentation, bilge pumps, and other provisions would be required.

Helicopter splashes off . . .
from Philadelphia waters after a simulated emergency landing. Permanently inflated floats keep whirlybird afloat, even permit taxiing.

US Cars Losing Favor in Europe

AMSTERDAM—American cars won't be able to maintain their portion of the European market. This is the consensus of observers attending the Amsterdam auto show. Prospective Dutch and other European buyers feel that American cars are getting too big for their garages and too unwieldy for European cities. Moreover, the glamour of American cars no longer appeals to European taste. European cars also, are produced in a number of styles and makes, and their road performance is constantly improving.

The very small cars—around 600 cc—are the hit of the RAI show. These big sellers, which a few years ago were little more than scooters or motorbikes, have become good looking, well-functioning automobiles with room for four passengers, including driver.

The 15.1% share of the Dutch market held by American cars in 1954 shrank to 5.8% last year. It is expected to shrink further. Big markets for American cars last year were West Germany in 1957 headed the list with 47.3%; France, 18.7%; Britain, 17.5%; Italy, 7.4%.

Cut USAF Repair Bill

DALLAS—A new concept involving replacement of complete assemblies, eg, electronic sybsystems, instead of replacing damage parts, was outlined at the Aviation Conference of ASME and American Rocket Society. Called disposal-at-failure maintenance, plan seeks to cut USAF's $4-billion plane repair bill. To make this pay, requirements must be anticipated at least three years in advance, and long-range supply must be considered.

RCA on the Receiving End of Indictment

WASHINGTON—Giant RCA, already the target of a handful of government and private antitrust suits, has now been hit by the biggest bombshell of all: a criminal indictment, obtained by the Dept. of Justice, charging RCA with an illegal conspiracy to monopolize the electronics-equipment field and the patents covering electronic inventions. RCA is also charged with participating in illegal cartel agreements with foreign electronic manufacturers.

The indictment, returned by Grand Jury February 21, contains four separate counts, each punishable by a fine of up to $50,000. The charges specifically relate to patents and parts used in "radio purpose apparatus," which includes radio, television, radar, sonar, and guiding and controlling devices used in missiles.

The indictment broadens the antitrust attack on RCA's patent position launched in 1954. The civil suit filed that year was limited to domestic operations.

A total of seven American companies are named as co-conspirators including General Electric, Westinghouse, American Telephone & Telegraph, Western Electric, and Hazeltine Corp. More than a dozen foreign companies from England, Holland, France, Germany, Australia and Canada are also named co-conspirators.

RCA has not commented publicly on the indictment beyond its original announcement stating the company had not had a chance to study the indictment and "for years RCA has licensed all comers under all patents . . . in order that companies in the industry might compete more vigorously and more effectively with each other and with RCA."

In addition to charging RCA with monopolizing the licensing of radio-purpose patents, the indictment charges RCA and the co-conspirators have agreed that:

General Electric, Westinghouse and AT&T shall not compete with RCA in licensing radio-purpose patents in the US;

RCA and certain of the foreign companies shall not compete in the home country of the other in licensing such patents; and

RCA and certain of the foreign companies shall not export competitive equipment to the home country of the other.

Observers are guessing that Justice Dept. lawyers will now press the criminal case, even though the 1954 civil suit still is being prepared for trial. Ordinarily, the government tries to get quicker action on criminal cases. And, because the criminal case incorporates most of the 1954 civil charges and adds some new ones, i.e., foreign activities, it's probable that the government will want to get a decision on the broader cast first.

TRIO OF USAF DEVELOPMENTS:

Automated Inspection, Metal-Bonded Ceramics Data Process Machine Tools

WRIGHT-PATTERSON AIR FORCE BASE—Ultrasonic inspection is about to become a fully automated, high-speed operation.

According to the Air Materiel Command, purpose is to detect internal flaws in plate, rod, and extrusions of aluminum, magnesium, steel and other metals. New method was developed by Sperry Products, Inc., under Air Force contract.

Automation is made possible by an improvement in the ultrasonic-Reflectoscope method of scanning for internal defects. The improved technique makes it possible to correct for distance in flaw detection by means of automatic correction circuits, a task which previously had to be accomplished manually by the reflectoscope operator.

Metals can be bonded to ceramics by an improved technique that speeds mass production of vacuum tubes. Metal powder is machine-pressed on both ends of the vacuum-tube's ceramic cylinder. This impregnates ceramic material with metal. A single operation then matures the ceramic, sinters the metal and develops the bond. Technique replaces added application of metal powder to the ceramic.

The new pressed-powder system was developed by American Lava Corp. under Air Force contract. Air Materiel Command calls the breakthrough a new approach to mass production of vacuum tubes for high-temperature applications.

First automatic data-processing system to provide information for numerically controlled machine tools is being developed jointly by Air Materiel Command, M.I.T. and the aircraft industry.

Designed by M.I.T., the new system eliminates much manual work needed to solve arithmetical problems before numerical controls can be fed. System is based on programming by two-dimensional curves—one longitudinal and one transverse. A three-dimensional system can be built by adding depth data. It will permit programming by areas.

Detroit Designers Not Hit by 13-yr Job Low

DETROIT—Though unemployment here has reached the highest peak since 1945, industrial designers in the area have not been affected.

Apparently manufacturers are turning to designers in an effort to dress up their products for added appeal in the shrinking buyers market.

Because the area's employment is pegged to automotive production, decline in employment reflects the thin times that have fallen on the automobile business. The layoffs are not restricted to production personnel; staff members in engineering and other functions are being quietly let go, and are not replaced as they leave.

This situation, originating in the large automobile companies, is spreading to some suppliers, and threatens to snowball.

READER TO EDITOR

Houseboats on Wheels

To the Editor:

Your editorial in the issue of Feb. 17, p. 65 is most excellent—congratulations! Also interesting is the confirmation of what you say, coming from Mr. McGillis. His statement, "The trend to bigger cars has received the endorsement of the public," (p. 20) is a remarkable attempt at establishing an excuse. (The mayor of New York is right, of course). McGillis should admit this: When you handle six or eight people, as in the case of a large family or a car pool, you need space accordingly; large vehicles have their uses. However, Detroit will give the prospective buyer no choice—they insist in forcing elephants on buyers who are looking for polo ponies. As usual, the public took its time to wake up. That the public should be responsible for the Detroit monsters is nonsense; they are based on no buyer's concept but on wild ideas conceived by sales managers (mostly self-styled). The mere fact that automobiles, however standardized their components may have become, look different every year is no tribute to common sense. In each succeeding year, Detroit implores the public to believe that—although their last year's model was discontinued—this time they have finally come up with exactly the right answer.

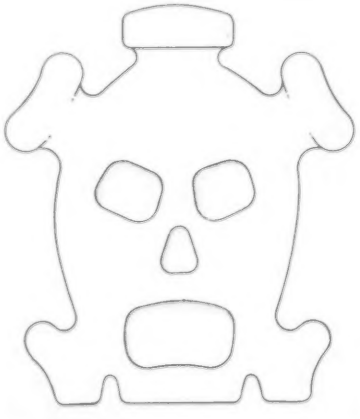
(The current issue of Detroit's creations looks somewhat like houseboats on wheels. Fortunately, as per your magazine cover, locomotives now look like locomotives, not like automobiles on wheels.)

Even McGillis must at times have noticed the unnecessary trouble and confusion caused by land vehicles with the proportions of river barges.

The actual reason for the ridiculous overdimensioning of cars as conceived in Detroit is probably that it costs relatively little to make a sheet metal box a little bigger. Conversely, a reasonably sized car for use by one or two persons could not be produced by Detroit at a price that would allow it to compete with non-Detroit products. A person likely to be impressed by mere bigness may find the bulky item attractive. What a buyer lets himself in for by acquiring a junior omnibus, high in fuel consumption, difficult to handle and almost impossible to park in most places, is apparently being discovered right now. *Quod erat demonstrandum.*

(American Motors' large sales increase, plus the invasion of the foreign car may be an awakening for the "Big three"—Ed.)

Perspectives, p. 63, reveals that map makers do not exactly oppose the metric system (Why should they?) but oppose the confusion within the British system. I will go one better on Dr. Astin. Instead of trying to put some order into the hopelessness that the British system represents (dating back to a time before the French Revolution and having never been amended since) I propose that he simply get used to the international (metric) system, and save all of us a good many headaches. In my humble opinion, the mere fact that we saddle ourselves with such a clumsy item as this, makes catching up with the scientific standards of others unnecessarily difficult.—MAX F. WULFINGHOFF
Erlanger, Ky.



Skull Bottle

To the Editor:

Here is an idea I've had that should prove a very functional item. It's a design for a bottle made from glass, polyethylene, vinylite or other suitable material, molded in the form of the accepted symbol found on labels attached to containers whose contents are poisonous. Since this symbol is known even to children, a bottle of this shape would be recognized, even though handled in darkness. Slight indentations would serve to indicate the openings in an actual skull.

This idea has previously been sent to several concerns, but because of low volume production of such an item, the companies weren't interested. Anyone interested may have it, no strings attached—M. O. YOUNG
All American Engineering Co.
Wilmington, Del.

24-hour Alarm Clock

To the Editor:

I notice that in the Dec. 16 (p 54) issue of your excellent journal, under the head of "Why Don't They Research and Develop," one of your contributors asks: "How about an alarm clock that rings only once in 24 hours?"

You may tell your correspondent that he, or she, is very many years behind the times as we first marketed a synchronous electric alarm clock with an automatic 24-hour reset device as long ago as 1935 —H. T. BAKER
Smiths Clocks & Watches, Ltd.
London, Eng.

Compass for Hidden Circles

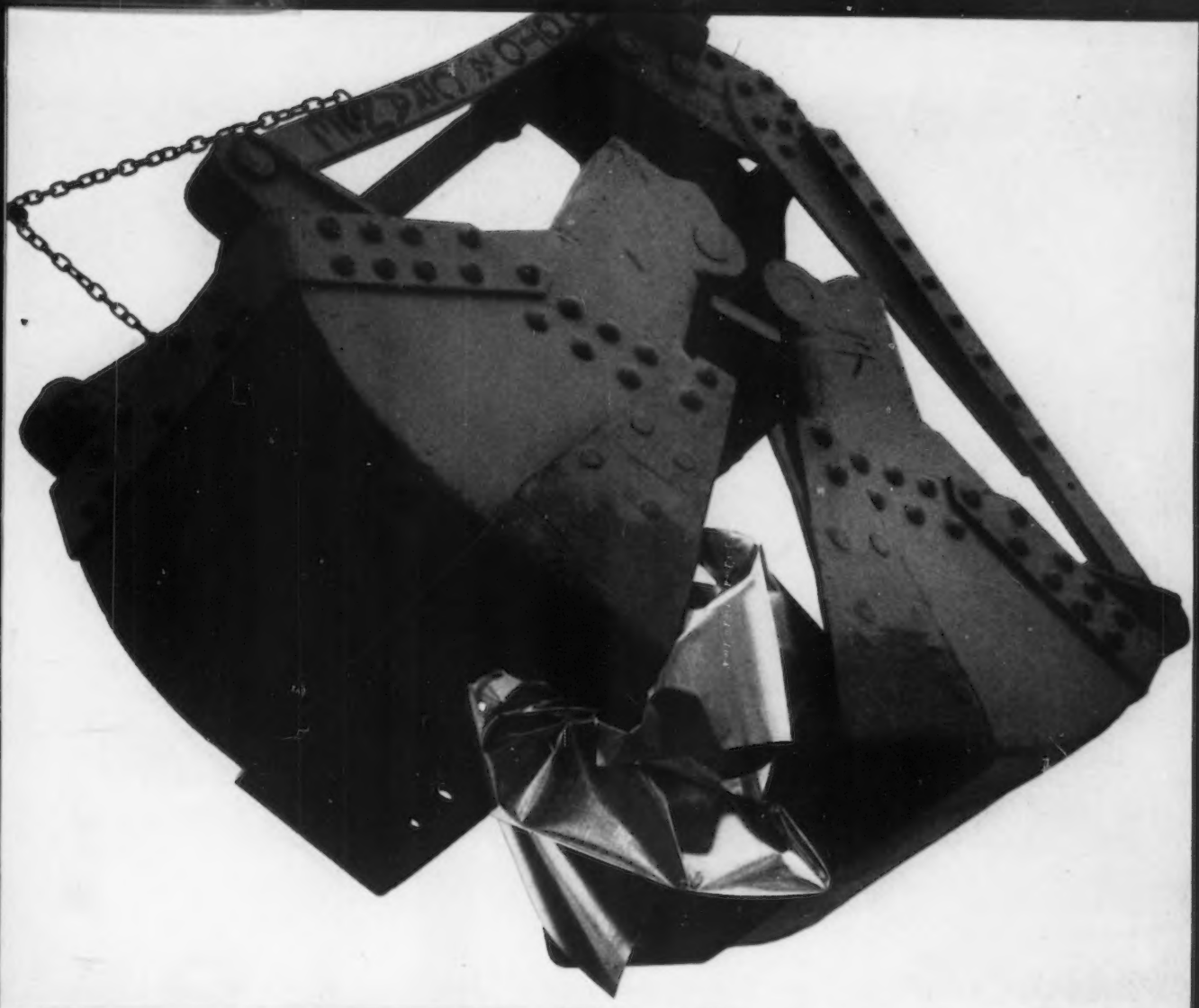
To the Editor:

It was indeed interesting to read Mr. T. N. Tyler's suggestion under your article, "Why Don't They Research and Develop" (Jan. 27, p 58), for a drafting compass to automatically produce dashed lines for representing hidden circles.

Mr. Tyler, on his own, must have been working parallel with a German company, Bayerischereisszeugfabrik AG, (under the trade name ECOBRA) of Nurnberg, Germany which has introduced on the market an instrument very similar to Mr. Tyler's.

I feel that this fills a very old standing gap in most draughtsmen's equipment and I hope will be soon welcomed by many.

—PATRICK SPENCE-THOMAS
Sales Engineer
Electrodesign
Montreal, Can.



SQUEEZE PLAY FAILS TO SCORE AGAINST WEIRKOTE

Crun-n-n-ch!

For brutal, iron-jawed pressure, a steam shovel has few equals. Here, in this crushing grip, Weirkote's zinc coating undergoes a murderous test.

Yet at every crease, at every tortured angle of this crumpled mass, the zinc remains an integral part of the steel. There is not one sign of flaking anywhere!

No wonder strenuous forming operations such as lock seaming are child's play, for Weirkote can be worked to the very limits of the steel itself!

No wonder parts fabricated from it require no painting, plating or redipping to guard against corrosion. Weirkote parts can be stamped, drawn or spun well in advance of use, and stored without danger of rust.

And NOW, Weirkote is treated to inhibit wet storage (white oxide) stain.

Why not find out what Weirkote's benefits can mean to you?

Free Weirkote Booklet! Send for all the facts on Weirkote. Write Weirton Steel Company, Dept. D-6, Weirton, West Virginia

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6 INTERNAL SPOKES WITHOUT MACHINING!

Another typical design application of Hunter Douglas Aluminum Cold Forgings.

Those radial spokes on the inside bottom face of this instrument case were held to ±.005" thickness and to .5° for location. Yet the complete case was instantly impact extruded from a starting slug of 6011 aluminum alloy! Except for simple secondary machining operations—trimming to length and drilling—the part is ready for final assembly, as forged.

Hunter Douglas Aluminum Cold Forgings assure *precision tolerances, no draft, minimum machining, high strength, no porosity, excellent surface finishes.* These rewarding advantages can also be yours when you design with Hunter Douglas cold forging in mind.

Want more information about this process? Ask for free booklet, "The Story of Aluminum Cold Forging."

These industrial parts, many with intricate shapes, are typical of thousands produced by Hunter Douglas Aluminum Division of Bridgeport Brass.

Hunter Douglas Aluminum Division of Bridgeport Brass Company • Department PE-3 3016 Kansas Avenue, Riverside, California

Specify Century for top performance in motor-driven equipment

The performance and acceptance of equipment in the field can depend on the motor that drives it. And the design of motor-driven equipment is not complete until the motor is specified. This involves careful consideration of motor type and of motor manufacturer as well.

A familiar scene in the engineering departments of leading equipment manufacturers finds Century Application Engineers helping to determine the correct motor for the job. They are often called in during the design and development stage. Through their know-how and experience they help select the motors to match the performance of the equipment.

Century motors write their own record of reliability. Get all the facts on why Century is your best motor investment. Call your local Century man or Authorized Century Distributor.

Century MOTORS

CENTURY ELECTRIC COMPANY

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compact . . . power-packed

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REDUCE YOUR

IMMEDIATE SHIPMENT of popular Tri-Clad '55' motor ratings—through 125-hp—is provided from factory, district warehouses, and distributor stocks.

TRI 55 CLAD motors can help you . . .

REG. U.S. PAT. OFF.

DELIVERY CYCLE

NOW AVAILABLE THROUGH 125-HP

CONVENIENT WAREHOUSE STOCKS provide immediate shipment of any popular G-E Tri-Clad '55' motor rating up through 125-hp. Nationwide stocks are maintained by distributors as well as 34 G-E district warehouses.

HIGH-SPEED PRODUCTION of all types of motors is provided by new automated manufacturing facilities. With these facilities, special-purpose motors are produced by General Electric almost as fast as standards.

G-E PRE-ENGINEERING SERVICE provides special motor designs to meet your immediate or future needs. Where conditions warrant, such motor designs could be stocked at nearby G-E warehouses to provide fast delivery.

immediate shipment . . . popular NEMA ratings

How many additional sales could your company have made this year if you could have delivered your product faster?

In today's highly competitive market, often just a few days can make the difference between a lost sale, and an important order for your factory.

NOW, TO HELP YOU REDUCE THE DELIVERY CYCLE OF YOUR PRODUCT, General Electric offers immediate shipment of popular Tri-Clad '55' motor ratings—up through 125-hp—from nearby warehouse stocks. Or, if you use a motor that is not standard, G.E. can give you faster shipment from the world's most modern motor manufacturing plant.

IF MOTOR DELIVERY TIME IS A FACTOR in your production scheduling, you can now reduce your delivery cycles, make shipment promises with more assurance, and give improved customer service.

FOR MORE INFORMATION on the complete Tri-Clad '55' motor line—now available through 125-hp, contact your nearby G-E Apparatus Sales Office or Authorized Distributor.

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GENERAL ELECTRIC COMPANY
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Please send me the following publications:

☐ **FREE BULLETIN (GEA-6602) describes advanced features of new Tri-Clad '55' motors through 125-hp.**

☐ **FREE SLIDE RULE (GEN-148) to determine weight and space-saving benefits of new Tri-Clad '55' motors.**

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Progress Is Our Most Important Product

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air circuitry:

a new term of importance to control engineers.

Air has come of age as a control medium. No longer is it confined to the simple jobs of pushing a clamping device, moving a lever, or blowing chips. No longer is an air circuit just a valve, reservoir, and cylinder. Today the most complex of industrial control problems can and are being solved efficiently with air.

Today, pneumatic circuits can be interconnected. They can be set to control a complex sequence of operations *automatically*. They can be combined with electrical circuits. There is *no* control problem you have that can't be solved successfully with air.

The new role that pneumatic control can play in industrial operations demands a new way of thinking about air control. It demands a new way to describe control by air—a new name that suggests some of its limitless control possibilities. That's why Westinghouse Air Brake Company is now using the term "air circuitry" to describe the application of air control to automation.

Westinghouse Air Circuitry, we realize, has to be more than *just as good* as your present means of control. It has to offer you *extra advantages*. And it does.

Chief among these is its extreme simplicity. The devices themselves are uncomplicated mechanical devices. They have few moving parts. They are easy to service by any mechanic. The circuit connections are made with pipe—and what could be simpler than that!

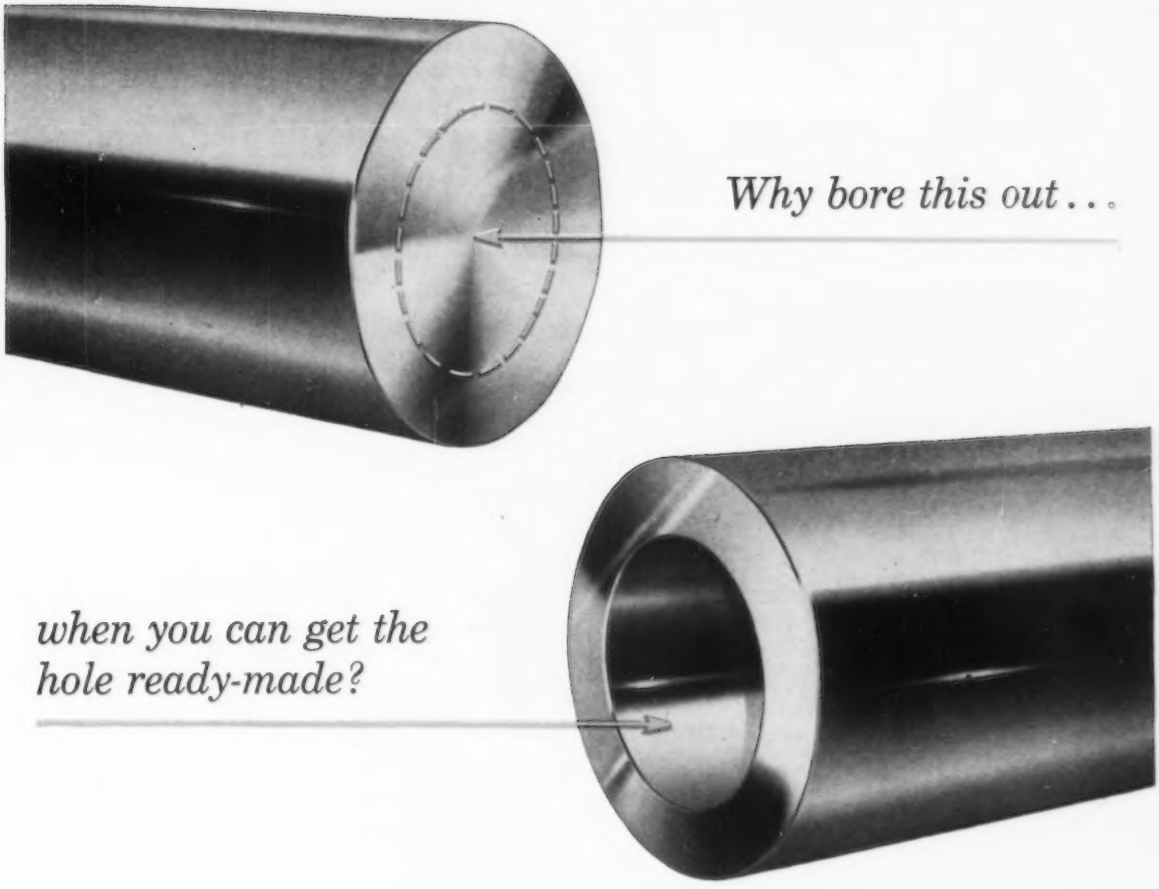
This extreme simplicity brings with it other important "pluses" for air circuitry. The simple equipment is unusually reliable—there are few moving parts to wear out or get out of adjustment. The devices are sturdy and durable. They require very little maintenance. What maintenance there is can be handled without the services of highly trained technicians.

Above all, remember: no means of control is as *safe* as air.

Air circuitry can help you simplify your control problems. It can help you get accurate answers to your automation problems on any industrial machine . . . in any industrial process. And Westinghouse Air Brake Company can help you with the engineering of a suitable system. Westinghouse has been in the control engineering business for 80 years now. It has been at the forefront of the development and improvement of air control equipment and its applications.

For more information on Westinghouse Air Circuitry—how it has helped other companies, how it can help you—write for your copy of "Basic Pneumatic Control," or call our nearest sales office.

WESTINGHOUSE AIR BRAKE COMPANY, INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PA.



Save money on hollow parts by switching from bar stock to TIMKEN® seamless steel tubing

Check these savings you get when you make hollow parts with Timken® seamless steel tubing instead of bar stock:

1. **NO HOLE TO DRILL**—it's already there.
2. **ELIMINATION OF COSTLY BORING OPERATION** frees part of your screw machines for other jobs—adds machining capacity *without* adding machines.
3. **MORE PARTS PER TON OF STEEL** because there's less metal to hog out.

And with Timken seamless steel tubing you get better quality finished products. The piercing operation by which Timken seamless steel tubing is made gives the tubing its fine forged quality. A solid round is forged over a mandrel, thoroughly working the metal inside and out. Accurate temperature and piercing speed control combine to produce uniform, fine forged quality. And we maintain this quality from tube to tube, heat to heat, order to order.

Timken Company engineers are always ready to study your problems, recommend the most economical tube size for your hollow parts job—a size guaranteed to clean up to your dimensions. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

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SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

NEW TESTS HIGHLIGHT ASSETS OF LEATHER PACKINGS

- **Flesh Side Out — lower friction regardless of impregnation**
- **Flesh Side Out — lower porosity regardless of impregnation**
- **Rubber Impregnation — lower friction than hard wax**
- **Rubber Impregnation — less leakage than hard wax**
- **Uniquely Designed Houghton 1243-3 Cups — superior to all other types**

DESIGNERS AND MAINTENANCE MEN both are interested in modern leather packings. Their resistance to abrasion and extrusion, their compatibility with modern fire-resistant hydraulic fluids, and their strength under high operating pressures spell long, trouble-free service and makes them ideal seals under many combinations of process conditions.

In response to the demand for further technical data on friction and porosity benefits from leather packings, Houghton engineers recently completed a comprehensive study of the conventional leather cup packings used in industry today. The findings are headlined above.

TEST RESULTS

Synthetic Rubber—(Houghton 1243-3) flesh out, flared wall, square shoulder

No. of Cycles	Friction Push	Friction Pull	Test Pressure	Pressure Increased To	Oil Loss Milliliters	Strokes Per Minute	Average Cylinder Temp.
500	20 lbs	0 lbs	500 psi			30	80°F
	25 lbs	0 lbs		1,000 psi		15	
700	25 lbs	10 lbs	1,000 psi			30	82°F
	25 lbs	10 lbs	"	2,000 psi		15	
900	40 lbs	10 lbs	2,000 psi		no measurable loss	30	83°F
	40 lbs	10 lbs		3,000 psi		15	
1,100	60 lbs	25 lbs	3,000 psi			30	84°F
	60 lbs	25 lbs		4,000 psi		15	
1,300	75 lbs	40 lbs	4,000 psi			30	85°F
	75 lbs	40 lbs				15	

Wax—Grain out, straight wall, round shoulder

No. of Cycles	Friction Push	Friction Pull	Test Pressure	Pressure Increased To	Oil Loss Milliliters	Strokes Per Minute	Average Cylinder Temp.
500	125 lbs	175 lbs	500 psi		32	30	80°F
	150 lbs	225 lbs		1,000 psi		15	
700	150 lbs	225 lbs	1,000 psi		38	30	100°F
	175 lbs	250 lbs		2,000 psi		15	
900	175 lbs	250 lbs	2,000 psi		40	30	105°F
	200 lbs	300 lbs		3,000 psi		15	
1,100	200 lbs	250 lbs	3,000 psi		41	30	110°F
	275 lbs	325 lbs		4,000 psi		15	
1,300	250 lbs	275 lbs	4,000 psi		42	30	115°F
	275 lbs	325 lbs				15	

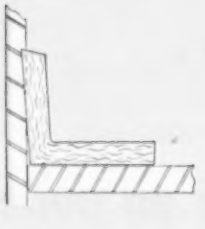
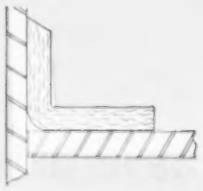


Diagram of cross section of 1243-3 packing illustrates square shoulder, side wall flare and pre-loading feature.



Rounded shoulders of old style cup packings which assume square shape after pressure is applied in use.

THE PACKINGS TESTED... included both wax and rubber impregnated types with round and square shoulder, flared and straight wall, and with flesh side and grain (hair) side of the leather as the contacting surface. In order to achieve equality in test conditions, all cups were identically spring-loaded when mounted.

JUSTICE MACHINE TESTING... The cups were driven for various numbers of cycles under different oil pressures in our Justice machine. In such tests highly accurate measurements of surface finish and power loss due to friction are made. A comparison of typical test results is shown at the left. Complete results are available on request.

FLESH-OUT THEORY... The porosity results substantiated a long-standing theory on the superior performance of leather packings moulded with the

flesh side out. According to this theory, moulding the flesh side out minimizes leakage because the tightly knitted grain surface is next to the pressure and does not wear away in service.

TOP PERFORMANCE OF 1243-3 CUP... The tests also reaffirmed the superior performance characteristics of Houghton's 1243-3 leather cup impregnated with synthetic rubber. The unique impregnation developed by Houghton researchers is much more than a surface coating. The liquid rubber polymer is actually channeled down among the fibers of the leather for a complete permanent impregnation which imparts the sealing qualities and pliability of rubber to the strong wear-resistant leather packings.

Houghton's unique synthetic rubber impregnation gives this 1243-3 leather cup the pliability and sealability of rubber.

ENGINEERING NEVER STOPS. The recommendations of a Houghton packing engineer are always based on facts obtained through tests like this leather packing study. Houghton developments include standard stack heights for "V" packings (making possible the interchangeability of packings of various materials without redesign of the gland). The pre-forming of square shoulders, and the spring mounting technique described above are Houghton developments. Houghton engineering has contributed to better packing materials, simplification of hydraulic systems engineering, more efficient hydraulic fluids.

When you specify Houghton packings you'll find on-time delivery and prompt service as much a part of our program as sound engineering. Check the full line at the right. Pick the packings you need and contact the Houghton Man or write for engineering data. Specific folders on each type are available. Write E. F. Houghton & Company, 303 West Lehigh Ave., Philadelphia 33, Pennsylvania.

HOUGHTON PACKINGS FOR HYDRAULIC AND PNEUMATIC SYSTEMS

"VIM" LEATHER PACKINGS

Over 140 combinations of leathers and impregnations have been developed by Houghton's research department, to fit nearly all conditions. They provide efficient seals against oil, brine, water, oxygen, phosphate esters and other mediums.

Cups, flange, "U", "V"—flat washers, discs and gaskets—for oil, air, water or gas applications—engineered for smoother, more positive sealing action at all pressures and temperatures up to 160°F.

"ViM" No. 1243-3 RUBBER-IMPREGNATED LEATHER PACKINGS

Our most recent packing development is the complete impregnation of leather packings with synthetic rubber. Thorough impregnation combines the durable strength of leather with the non-porosity and resilience of rubber—easy to install, excellent sealing and less friction at low and high pressures.

"VIX-SYN" SYNTHETIC RUBBER PACKINGS, O-RINGS

Our special moulding process results in a more compact structure, and more uniform density. Line includes homogeneous and fabricated packings, gaskets, O-rings—and "Vim" leather back-up washers designed for use with Vix-Syn O-rings.

GET THESE HANDBOOKS DESCRIBING HOUGHTON PACKINGS AND ENGINEERING SERVICE

1. "Handbook on Leather Packings" includes complete data on hydraulic and pneumatic applications.
2. "Handbook on Synthetic Rubber Packings" provides valuable information for design engineers.
3. "Packing Standards"—Houghton's latest edition accepted as the standard handbook on leather and synthetic rubber packings for hydraulic and pneumatic applications.

A COMPLETE FAMILY OF FLUIDS, TOO

"HYDRO-DRIVE" PETROLEUM BASE HYDRAULIC OIL

Houghton's high quality hydraulic oil is fortified for maximum efficiency.

"HOUGHTO-SAFE" FIRE-RESISTANT HYDRAULIC FLUIDS

Water-base and Phosphate Ester types.

HYDROLUBRIC F.R.

Emulsion type fluid.

"HYDROLUBRIC" ADDITIVE FOR WATER

For closed water hydraulic systems.

PACKINGS

... products of

E F HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

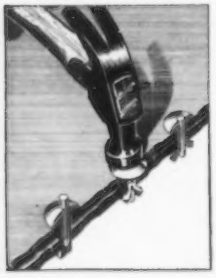
Ready to give you on-the-job service...

MANY FACTORS CONTRIBUTE TO LOW INSTALLED COST OF SOUTHCO DRIVE RIVETS . . .

ECONOMICS OF FASTENING COVERS FULL CYCLE FROM INVENTORY REQUIREMENTS TO FINISHED PRODUCT

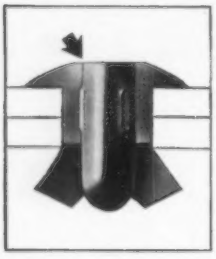
Designers who specify fasteners realize the many considerations that enter into cost determination. While ease of installation is often the most important feature, other factors affect costs. It may be difficult to put a dollar value on availability, for example, but serious financial losses do occur when production is held up or shipping dates are missed because of a slow fastener delivery. Being able to ship from stock, as Southco does, helps avoid production delays.

ELIMINATION OF SPECIAL TOOLS



Down time due to special tool failure and maintenance of special fastening tools are two fastening costs which are eliminated by Southco Drive Rivets. The only tool required is a hammer . . . any kind of a hammer . . . claw or ball, and size is not important. The number of men on a Southco riveting job is never limited by the number of special tools on hand and in working order.

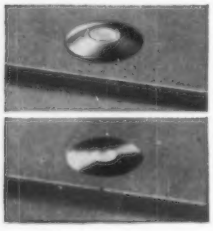
QUICKLY SET



To install, Southco Rivets are placed in drilled hole. The pin is then driven with a hammer. Installation is complete. No bucking is required.

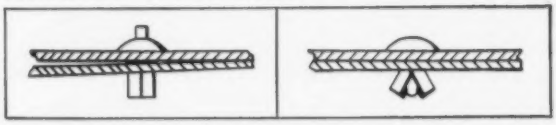
Expanded prongs force parts together. Pin is locked securely into rivet by displaced metal filling unique grooves. Compression forces are utilized for greater strength.

NO FINISHING OFF, NO WASTE



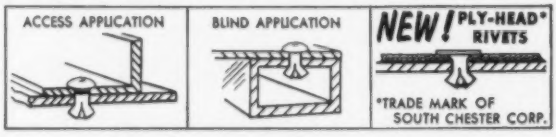
Impact of hammer seals pin neatly in rivet. No part of the rivet is cut off and discarded. No time-consuming filing, grinding or polishing is necessary. No scrap to clean up

AUTOMATIC "PULL-UP" ACTION ASSURES TIGHT JOINT



Even when adjacent surfaces are separated, parts are forced together by Southco Rivet action, then held tightly in compression.

WIDE RANGE OF APPLICATION



Southco Drive Rivets are used to secure metal to metal or metal to wood. They are equally adaptable to blind or open applications. In each, they are quickly set and grip tightly. New PLY-HEAD* rivet permits higher loading of "soft" materials such as plywood, plastics and composition.

AVAILABLE IN ALUMINUM OR STEEL

Southco Rivets are supplied in aluminum or cadmium plated steel. The aluminum rivets have either cadmium plated or stainless steel grooved pins. The steel rivets have cadmium plated steel grooved pins.

Standard head designs are Universal or Countersunk. Full Brazier heads are available in popular sizes. New PLY-HEAD rivet rounds out line.

ALUMINUM

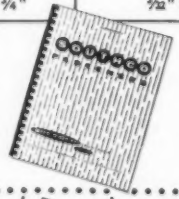
DIAMETERS	LENGTHS	NOMINAL GRIPS
1/8"	1/8" to 1/2"	1/32" to 13/32"
5/32"	7/32" to 3/4"	1/16" to 3/8"
3/16"	1/8" to 3/4"	1/32" to 3/8"
1/4"	7/32" to 3/4"	1/16" to 3/8"

STEEL

DIAMETERS	LENGTHS	NOMINAL GRIPS
1/8"	1/8" to 1/2"	1/32" to 13/32"
3/16"	1/4" to 3/4"	3/32" to 3/8"
1/4"	1/4" to 3/4"	3/32" to 3/8"

FREE FASTENER HANDBOOK . . . Send for your free copy of Fastener Handbook No. 7, just released. Gives complete engineering data on these and many other specialty fasteners. 52 pages, in two colors.

Write on your letterhead to Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.



SOUTHCO FASTENERS

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LION

This jewelry chain of **COPPERPLY®** wire might give you a gem of an idea!

• Copperply wire, a National-Standard development, is a steel wire, electroplated with copper to required thickness and with unmatched coating uniformity and concentricity.

It makes sense for jewelry chain manufacturers to use Copperply wire instead of copper or brass wire, because material costs are greatly reduced. It also provides an ideal base for plating if desired, it excells in strength, and provides more footage per pound with resultant production and handling economies.

To date other uses in light coating weights include: wrapping for piano wires, reinforcement for eyeglass temples, decorative tinsel, fanning mill cloth, and springs where a combination of power and electrical conductivity is needed. A major use in heavy coating weights is in the field of communications.

Here we touch only briefly on a few of the unique Copperply features, but perhaps enough to spark an idea worth exploring. And you'll find that the word "cooperation" has real meaning at National-Standard . . . whether your interest lies in Copperply wire or any of our other products. Try us.

NATIONAL NS NATIONAL-STANDARD Company **STANDARD**

DIVISIONS: NATIONAL-STANDARD, Niles, Mich.: *fine wire, stainless, music spring and plated wires* • **WORCESTER WIRE WORKS, Worcester, Mass.:** *music spring, stainless and plated wires, high and low carbon specialties*
WAGNER LITHO MACHINERY, Secaucus, N. J.: *metal decorating equipment* • **ATHENIA STEEL, Clifton, N. J.:** *flat, high carbon spring steels* • **REYNOLDS WIRE, Dixon, Ill.:** *industrial wire cloth*

THE WORLD'S FIRST CARD-OPERATED MILL,

PROMISES YOU BETTER STEEL—AUTOMATICALLY

HIGHER QUALITY

MORE
UNIFORM SIZE

BETTER
PHYSICAL PROPERTIES

New method provides a large file of schedules for various types of steel.

General Electric engineers, working closely with AL personnel, developed and installed the control systems which regulate the mill.

Better quality, more uniform steel is the result.

A NEW punch-card control system, recently installed on the 56" universal roughing mill at Allegheny Ludlum's Brackenridge, Pa. plant, is advancing mill standards of quality control.

Here's how it works: Allegheny Ludlum rolling experts predetermine optimum rolling procedures for the type of steel desired and translate this data into punches on an IBM card. These punches represent the proper screwdown settings, mill speed and number of passes. When the mill schedule calls for it, the mill operator in the pulpit simply selects the proper card, inserts it into the card reader, and he is ready to roll. As the operator makes each pass, the mill is automatically adjusted for each additional pass required. The rolled material is held uniformly to desired dimensions, and day in, day out it proves to have better, more constant physical properties.

It's easy to see how this kind of progress fits into your interest in consistent high quality. By performing rolling operations exactly the same way time after time, this new unit further assures Allegheny Ludlum customers that they are getting the best possible product from the industry's pioneer producer.

Let us talk over your requirements with you. Write us, or call the Allegheny Ludlum sales office nearest you, and an AL sales engineer will help you with any problem. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania.***

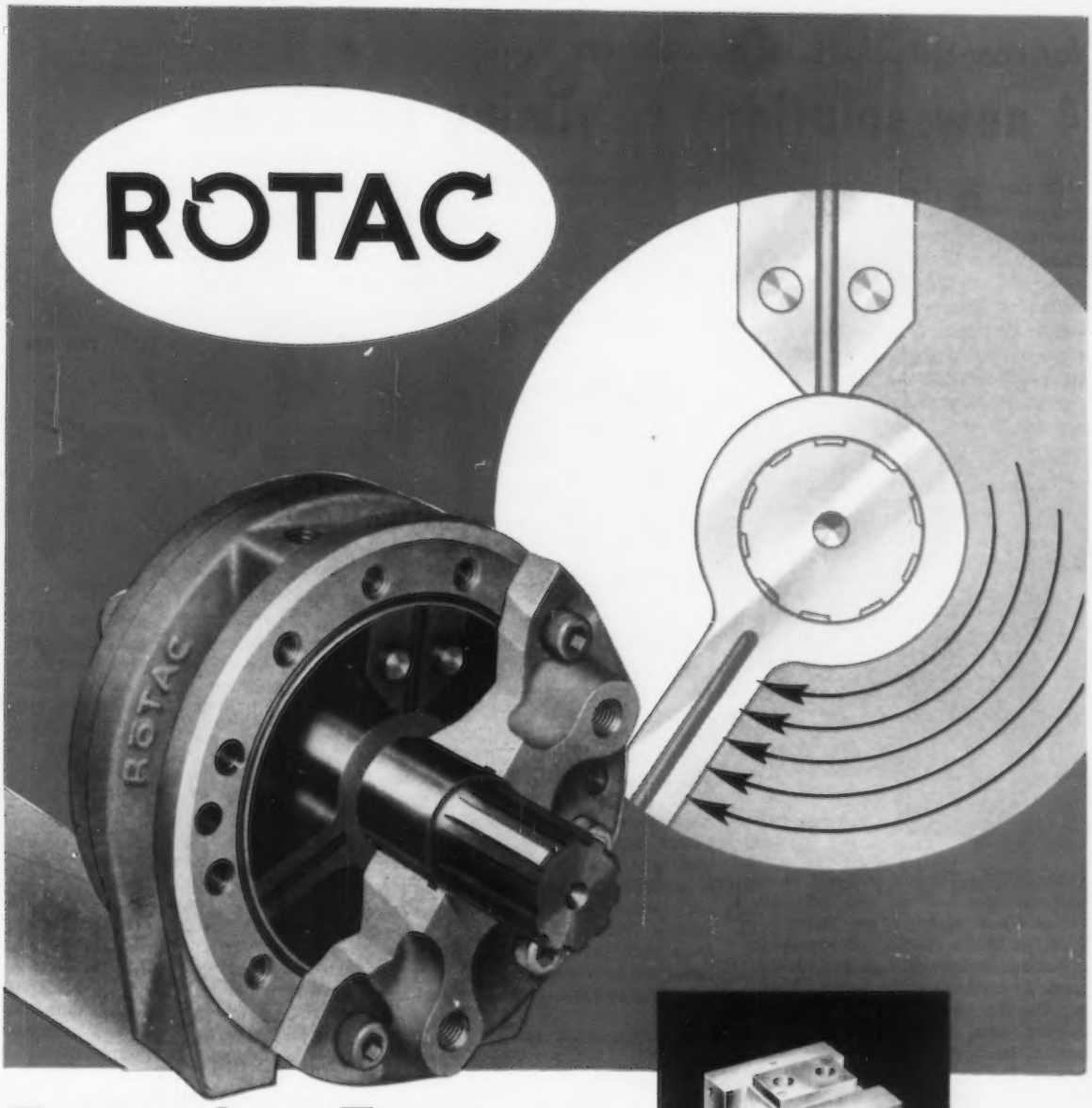
WSW 6626

PIONEERING on the Horizons of Steel

Allegheny Ludlum

AL ALLEGHENY LUDLUM

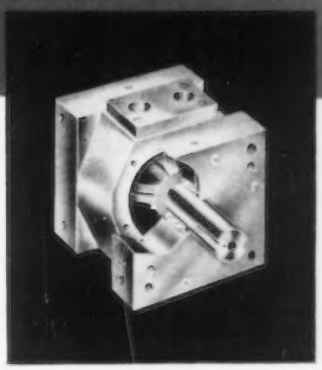
RŌTAC



Tremendous Torque in Small Space

If you are at all concerned with an operation involving power transmission, you owe it to yourself to investigate this new name in reciprocating torque actuators: Rōtac.

The name, Rōtac, may be unfamiliar to you because of its very newness—but the name (and reputation) of Ex-Cell-O should excite your interest. Even now, Rōtac reciprocating torque actuators are performing such operations as clamping, indexing, lifting, revolving, lowering, extending, retracting, closing, opening, oscillating and turning, on a wide variety of machinery.



XLO

EX-CELL-O FOR PRECISION

945 E. SATER ST., GREENVILLE, OHIO

FREE LITERATURE

If you move *anything*, then you'll want detailed information on Rōtac. Learn how this rotary power is used throughout industry in thousands of applications. Complete with photos, schematics, engineering data, etc. 57-59

EX-CELL-O CORPORATION

EX-CELL-O PRECISION PRODUCTS INCLUDE: MACHINE TOOLS • GRINDING AND BORING SPINDLES • CUTTING TOOLS • TORQUE ACTUATORS • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • DAIRY EQUIPMENT

(*Advertisement*)

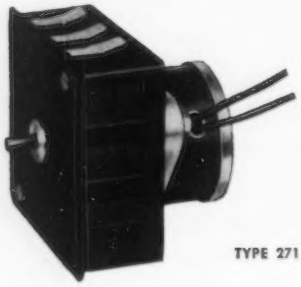
for cost-conscious manufacturers . . .

4 new solutions to timing problems

Over the years, Cramer engineering and manufacturing skill has built an unequalled reputation for quality in timers and timing motors. Today, the same skill . . . plus cost-cutting innovations in production methods . . . brings you four new units with the same outstanding quality at substantial price savings. Ask for prices, get the detailed specifications, and you'll see that Cramer quality means economy *now* — not just in the long run.

Cramer Controls Corporation
Box 7, Centerbrook, Connecticut

New Interval timer



TYPE 271

Cramer Type 271 is a compact, manually-set timer for "on" and "off" control of a wide variety of equipment . . . such as driers, ovens, photographic apparatus, battery charges, and various types of production machinery. Turning the dial pointer clockwise to the desired setting transfers the load switch, starts the motor and initiates timing. The pointer then indicates timing progress as it moves back toward zero. At the end of the set time, the load switch transfers to its first condition, and the motor stops.

TIME RANGES: 11 standard ranges, from 45 seconds to 24 hours.

LOAD SWITCHES: 1 or 2, as required; SPDT open blade.

CONTACT RATING: 30 amps resistive load, or ⅓ hp. motor load, at 115v A.C.

TIMING ACCURACY: within ½ of 1% of full scale time.

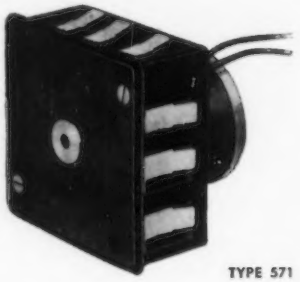
CONSTRUCTION: rugged, industrial design, using heavy-duty components.

POWER REQUIREMENTS: standard A.C. (50 and 60 cycle) and D.C. voltages.

MOUNTING: 2-hole face mounted, or single center hole.

WRITE FOR BULLETIN PB-271

New Cycling timer



TYPE 571

Cramer Type 571 provides reliable and inexpensive repetitive switching, or programming, in a wide variety of built-in applications . . . such as vending machines, displays, domestic appliances, production or process equipment, and many others. The timer starts when power is applied, stops if power is interrupted, and resumes cycling at the same point when power is restored. It can be wired for single cycle and stop operation, or for continuous cycling. During each cycle, 1 to 4 load switches are actuated, at times and for durations determined by cams cut to the user's specifications.

SPEEDS: 18 standard speeds, from 1 rpm to ⅛ rpd.

LOAD SWITCHES: 1 to 4 as required; SPST or SPDT, open blade.

CONTACT RATING: 30 amps resistive load, or ⅓ hp. motor load, at 115v A.C.

CAMS: precision-cut to user's programming requirements, locked to a square shaft that eliminates slippage.

TIMING ACCURACY: within 1½% of full cycle at each operating point.

CONSTRUCTION: rugged, industrial design, using heavy-duty components.

POWER REQUIREMENTS: standard A.C. (50 and 60 cycle) and D.C. voltages.

MOUNTING: 2-hole face mounted, or single center hole.

WRITE FOR BULLETIN PB-571

2 new timing motors

TYPE 117M

TYPE 117N

Cramer Type 117M and Type 117N are unequalled examples of performance-plus-economy in permanent-magnet synchronous timing motors. Delivering a full 30 in. oz. torque at 1 rpm, these powerful, accurate, reliable motors incorporate all of the engineering advances that have made Cramer the first choice of designers who put quality first. And their low cost is fast making them the first choice of large volume manufacturers who must put economy first. With standard gear train (Type 117M) or space-saving round gear train (Type 117N), a great range of standard speeds, and enough torque to handle the heaviest loads without extra linkages, they are ideal for appliances, vending machines, animated displays, timers, recorders, instrument drives, and many other applications.

SPEEDS: Type 117M—60 rpm to ½ rpd; Type 117N—60 rpm to 1/12 rpm. Special speeds available on order.

TORQUE: 30 in. oz. at 1 rpm.

GEAR TRAIN: fully enclosed, precision hobbed throughout.

OUTPUT SHAFT: stainless steel, selected to order from many standard or special forms available.

ROTOR: permanent magnet, with bronze oilite bearings and permanent lubrication; low rotor speed permits wide range of output speeds.

ROTATION: right, left, or dual (oscillating); patented "No-Back" mechanism; synchronous speed reached within 2 powerline cycles:

FRICTION: 1-way in rotation direction, or 2-way.

TEMPERATURE RISE: 35°C.

AMBIENT TEMPERATURE: −4°F to +131°F.

RATINGS: 115v and 220v, 60 and 50 cycles.

WRITE FOR BULLETIN PB-117

WHEN TIME IS YOUR PROBLEM, CALL CRAMER

CRAMER CONTROLS
CORPORATION

See us at the Design Engineering Show, Chicago — April 14-17 — Booth 1077

Modernize your v-belt drives with

TAPER-LOCK SHEAVES

—proved in over a million installations!

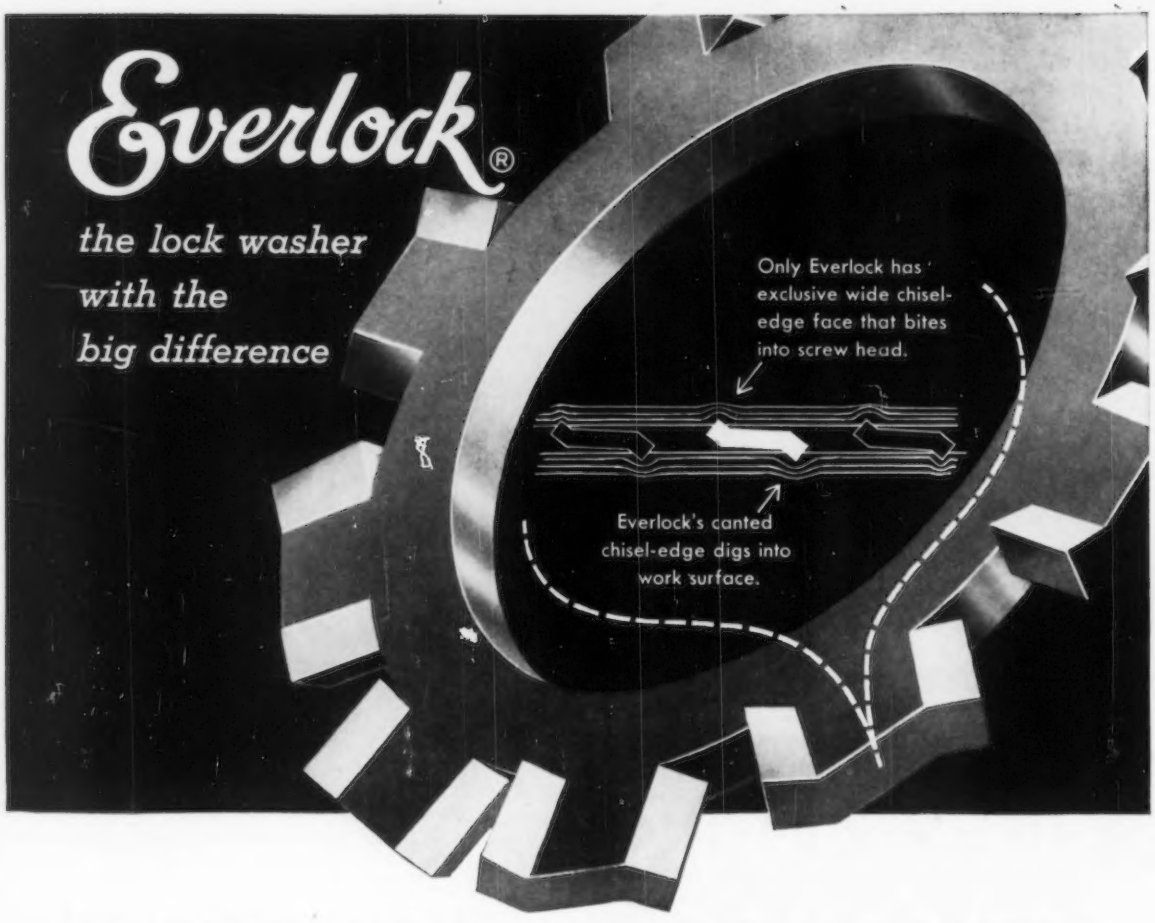
- **No flange. No collar. *It's different.***
- **Easy on — easy off.**
- **Just tighten the screws that wedge the bushing. Simple, isn't it?**
- **Always a perfect fit on shaft — tight as "shrunk-on."**
- **Complete range of sizes. A, B, C and D grooves, in stock.**
- **Try it—and you'll standardize on it!**

Taper-Lock Sheaves, with their precision machining, team up with matched Sealed-Life V-Belts to insure steady performance and unusually long belt life.

DODGE MANUFACTURING CORPORATION, 1200 Union St., Mishawaka, Ind.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

DODGE
of Mishawaka, Ind.


Everlock®
the lock washer with the big difference
Only Everlock has exclusive wide chisel-edge face that bites into screw head.
Everlock's canted chisel-edge digs into work surface.

THE BROAD DEEP-BITE GRIPPING POWER

Here is the big difference between Everlock and other lock washers. Everlock's exclusive canted chisel-edge lock washer bites into screw head and work surface, and grips tightly under severe strain, vibration or jarring impact.

Men who design and engineer modern-day equipment specify Everlock washers either for "over-the-thread" usage or for preassembly on Sems. They know their assemblies will last longer in the field because of Everlock's greater gripping power.

EVERLOCK "over-the-thread" and "Sems" washers are available in all sizes and types.

Send us a sketch of your fastening problem, material to be used, and load requirements. We will recommend the Everlock lock washer to fit your need.

Write for Free Catalog

Another AMF Product
Everlock
INDUSTRIAL FASTENERS

the complete line of lock washers

• Internal • External • Internal-External • Countersunk • Spring lock • Dished toothed periphery type • Dome toothed periphery type • Dome plain periphery type • Specials

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THOMPSON-BREMER & CO.

Dept. P, 228 North LaSalle Street, Chicago 1, Illinois Subsidiary of AMERICAN MACHINE & FOUNDRY CO.

A significant announcement.

TO STIMULATE AND ENCOURAGE THE IMAGINATIVE EMPLOYMENT OF PLASTIC MATERIALS

THE BACHNER AWARD

. . . for excellence in the application of plastic materials, established by the CHICAGO MOLDED PRODUCTS CORP. and named to honor the Company's founders, is to be awarded in Chicago at the time of the forthcoming National Plastics Exposition. The Bachner Award is for an outstanding contribution to the practical application of molded and formed plastics to the products of industry. The winning company will receive an inscribed plaque, and the individual(s) designated by the company as being most responsible for the achievement will receive $1,000. Honorable mention citations will also be awarded. Entries must be received by August 15. Complete information and entry forms are obtainable from The Secretary to the Committee, Mr. William T. Cruse, c/o Society of the Plastics Industry, Inc., 250 Park Avenue, New York 17, N. Y.

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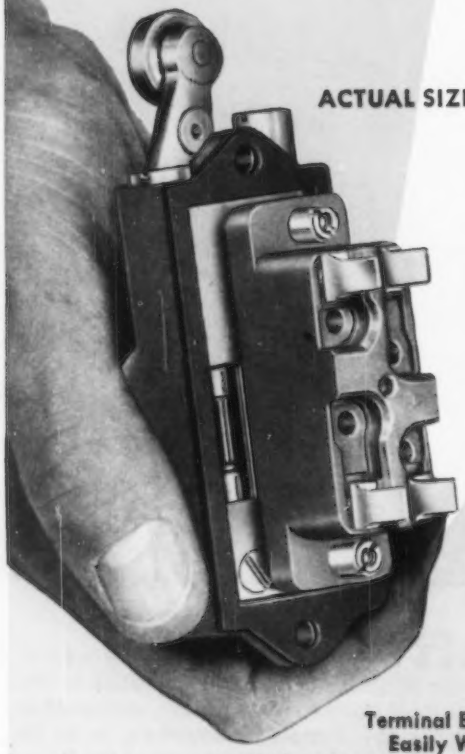
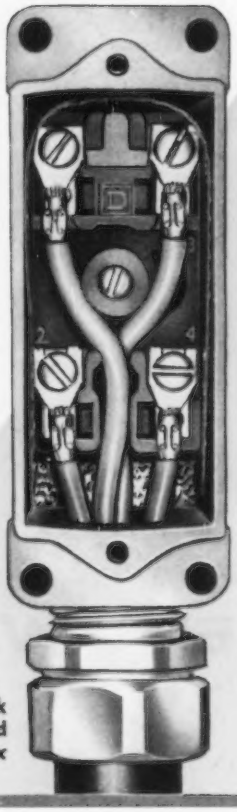
This New PLUG-IN LIMIT

CLASS 9007, TYPE AW



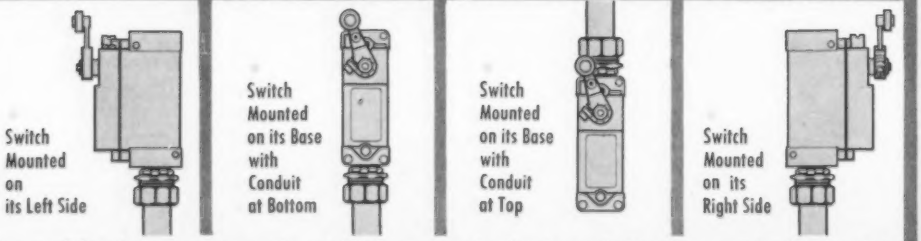
ACTUAL SIZE



Terminal Block Easily Wired *Without Removing from Box*

- Oil-tight construction
- Switch plugs in—in seconds
- Mounts without disassembly
- Wired without removing from box
- Reversible plug-in unit —can be plugged-in with roller arm at either end
- Switch action can be reversed by simple screwdriver adjustment
- Present installations easily converted to plug-in
- Precision switch mechanism —only 5° to operate— 25° overtravel in either direction
- Graduated markings around hub of roller arm simplify accurate settings
- Same price as standard Square D oil-tight limit switch

6 MOUNTING ARRANGEMENTS...WITH 1 DEVICE!


Switch Mounted on its Left Side
Switch Mounted on its Base with Conduit at Bottom
Switch Mounted on its Base with Conduit at Top
Switch Mounted on its Right Side

In any of the above arrangements, conduit can enter at either top or bottom by reversing box position

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

SWITCH is SO EASY to Use!

SQUARE D LIMIT SWITCHES ARE Designed TO DO HUNDREDS OF JOBS — BETTER!

SMALL OIL-TIGHT LIMIT SWITCH -- CLASS 9007, TYPE AW

Surface mounting, roller arm operated

Flush mounting, push rod operated

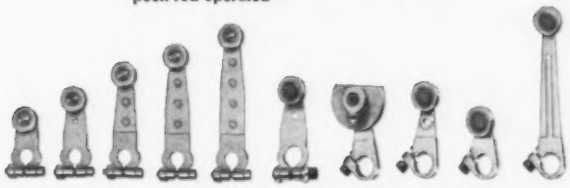
Surface mounting, push rod operated

Duplex switch, surface mounting, push rod operated

Duplex switch, flush mounting, lever arm operated

Flush mounting, lever operated

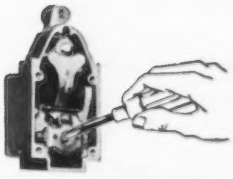
ROLLER ARMS AVAILABLE IN WIDE RANGE OF DESIGNS AND LENGTHS...



HEAVY-DUTY OIL-TIGHT LIMIT SWITCH -- CLASS 9007, TYPE T

Continuously adjustable lever arms, up to 80° overtravel

Transparent plastic cover available for instant inspection



Eleven contact arrangements in one switch; only a screwdriver is required

Rear shaft design for inaccessible locations

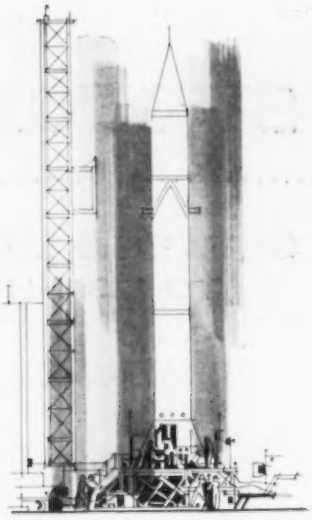
Many sizes and types of operating arms

WIDE VARIETY OF BASE PLATES AND MOUNTING HOLES...

Write for BULLETIN 9007 AW to Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

Quality... from start to finish!

Versatile ACIPCO Centrifugally Spun Tubes



Look at that surface! Belt-polished to ±.0015″ tolerance and 25 microinch finish, this 20′ long, 26.25″ OD, Type 4130 steel tube was produced at ACIPCO for use as a hydraulic cylinder plunger. This application graphically demonstrates the completeness of ACIPCO's extensive Machine Shop facilities.

ACIPCO can turn and finish up to 60″ diameters and 41′ lengths . . . hone up to 29″ ID's and 16′ lengths. Turning, honing and other related machining equipment occupy more than 100,000 square feet of modern Machine Shop construction.

ACIPCO tubes are available to you "Custom Spun" in lengths up to 16′. . . diameters up to 50″. . . and thicknesses up to 4″. Welded assemblies can be supplied in any transportable length. ACIPCO produces standard and special analyses in steel and cast iron, including heat and corrosion resistant stainless steels. Tubes can be furnished as-cast, rough machined or finish machined, including honing.

Investigate the plus advantages of Acipco's "one-source — from start to finish" service. Write for full information or technical assistance.

SPECIAL PRODUCTS DIVISION

AMERICAN CAST IRON PIPE CO.

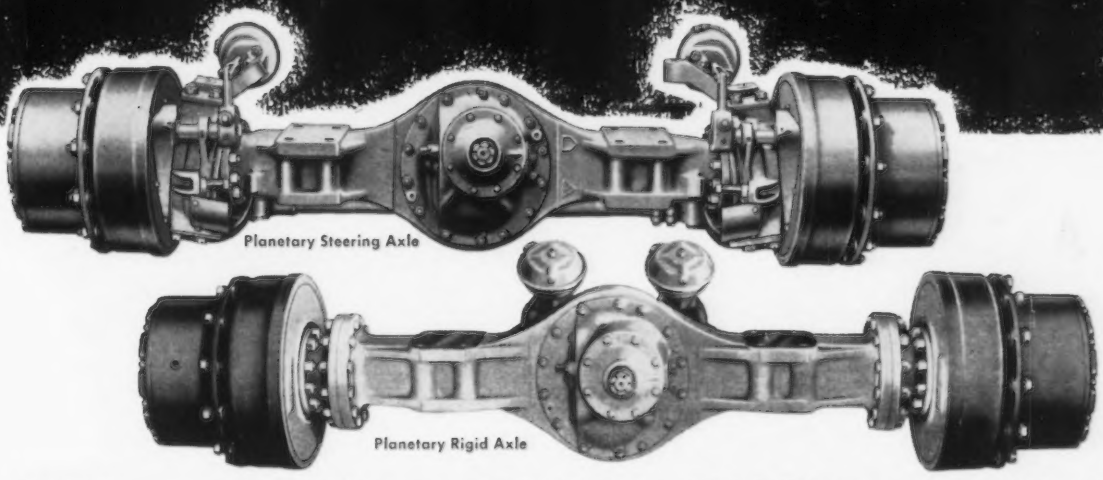
BIRMINGHAM 2, ALABAMA

FOR HEAVY-DUTY SPECIAL EQUIPMENT AND TRUCK APPLICATION...

TIMKEN-DETROIT®

NOW OFFERS TODAY'S BROADEST RANGE OF

PLANETARY AXLES..



Planetary Steering Axle

Planetary Rigid Axle

steering and rigid, from 20,000 to 75,000 lb. capacities!

A complete range of new, heavy-duty planetary axles—with a steering axle operationally matched to each rigid axle in the line—is now included in the Timken-Detroit family of advanced design axles. This matching of steering and rigid units brings you just the right axles for every requirement in both special off-the-road equipment and heavy-duty trucks.

Because of their versatility, ruggedness and gear reductions, these refined, full planetary axles are going into use all over the world on heavy-duty prime movers, big rugged four-wheel-drive tractors, heavy off-road rock wagons, mining equipment, heavy-duty road scrapers, front-end loaders, new agricultural equipment—and for many other additional heavy-duty applications.

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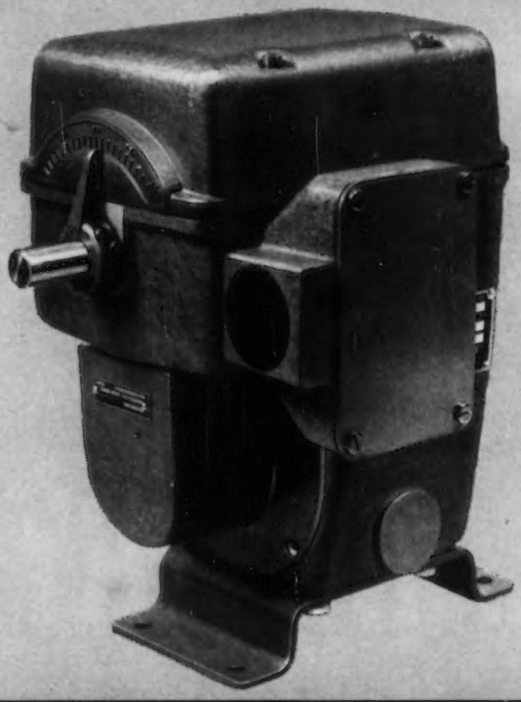
Plants at: Detroit, Michigan
Oshkosh, Wisconsin • Kenton and Newark, Ohio
New Castle, Pennsylvania

TIMKEN Detroit AXLES
TIMKEN-DETROIT AXLE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
DETROIT 32, MICHIGAN
Accepted SAE Standard

WORLD'S LARGEST MANUFACTURER OF AXLES FOR TRUCKS, BUSES AND TRAILERS

Products of ROCKWELL SPRING AND AXLE CO.

has the power you need for high accuracy in many electric control applications



New INDUSTRIAL VALVE MOTOR SERIES 831E

Designed primarily for valve or damper applications, Honeywell's powerful new Industrial Valve Motor is suitable for many other control applications where high accuracy and reproducibility are required. It rounds out the complete line of Honeywell pneumatic and electric industrial motors.

Some of its outstanding features:

- Positive control action without coasting.
- Accurate positioning of final control elements over full drive shaft rotation.
- Over-travel protection for the slidewire.
- Arc-suppression circuit to protect auxiliary relays.
- Readily accessible internal components.
- Variety of speeds (3 to 120 seconds) and modes of control available.
- Rated output torque—up to 62.5 ft. lbs.

For complete details on the new Series 831E Industrial Motor, write for Specification S-804-2, or call your nearby Honeywell field engineer. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

The **ACTIONATOR*** gives dependable, low-cost service where the application calls for medium power.

Operate valves, dampers, louvers and other final control elements with this rugged, lightweight industrial motor. It's available with on-off, two-position, floating or proportional control. Its features include:

- **High torque ratings**—to 200 inch-pounds.
- **Fast speeds** available to meet application requirements.
- **Internal brake** to hold load in any position without coasting or hunting.
- **Easy adjustments**—readily accessible, field adjustable, cam-operated travel and auxiliary switches.

For details, write for Specification S-804-3, or call your nearby Honeywell field engineer.

**Tradename Minneapolis-Honeywell Regulator Co.*

Honeywell

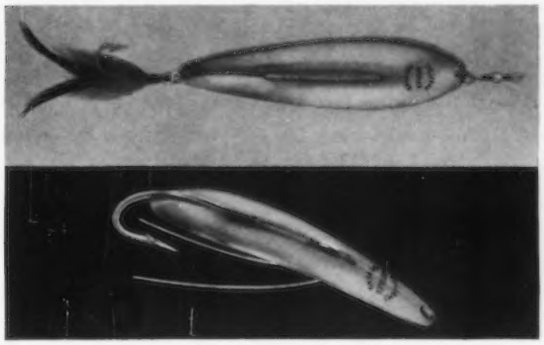
H HONEYWELL *First in Controls*

NEW BRASS CUTS POLISHING COST

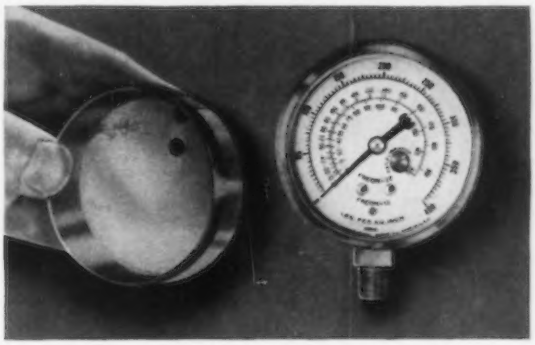
also gives you clean, easy drawing and forming, plus higher physical properties — Formbrite,® Superfine-Grain Drawing Brass by Anaconda

AIRGUIDE Instrument Co., Chicago, gets high luster finish on bezels for its famous weather instruments at 50% lower cost since it switched from ordinary drawing brass to Formbrite. Airguide does the presswork—says Formbrite "draws and forms excellently." Driscoll & Co. (above) polishes the bezels.

BAROMETER in Chippendale style, "Mayfair," is one of the broad line of brass-trimmed instruments made for home and marine use by Airguide.



FISHING LURES made by Williams Gold Refining Co., Inc.—"Wabler," top and "Weedler," below—are polished for plating by tumbling. Switching from ordinary yellow brass to Formbrite cut costs more than 40%.



MARSH Instrument Co., Skokie, Ill., dropped a finishing operation and gets a "mirror finish" with a light buff, by using Formbrite. Marsh reports that finishing cost was cut 40% and that forming is "excellent."

Wherever finishing is an important cost factor in formed or drawn products, Formbrite in sheet and strip is designed to save you money. In brass wire alloys for cold-heading and upsetting, it gives a stronger, springier, more abrasion-resistant product. For more detailed information, write for Publication B-39. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

5843

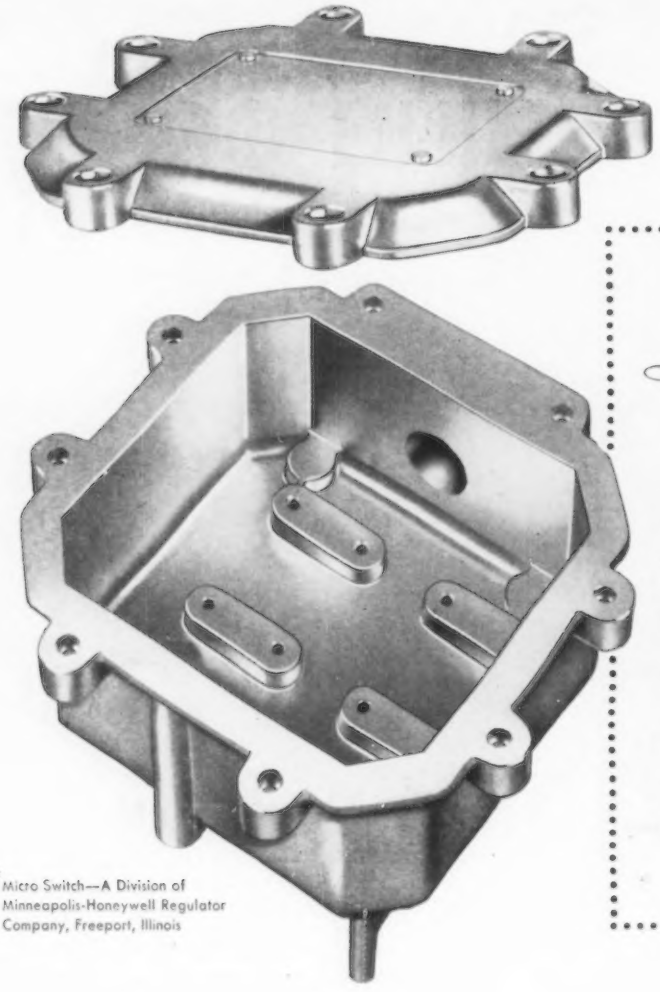
FORMBRITE

SUPERFINE-GRAIN DRAWING BRASS

a product of

ANACONDA®

Made by The American Brass Company



*Micro Switch—A Division of Minneapolis-Honeywell Regulator Company, Freeport, Illinois

Lifetime Quality

with MADISON-KIPP zinc and aluminum die castings

The earmarks of lifetime quality are never elusive. They are there to see in dis-assembled, unpainted components. They are there to see in break-down tests.

The Kipp die cast body and cover of the *Micro Switch instrument here illustrated are of lifetime quality not only to encase and protect functional parts, but also to provide a rigid frame, ample bearing bosses, stable dimensions, and other last word engineering features.

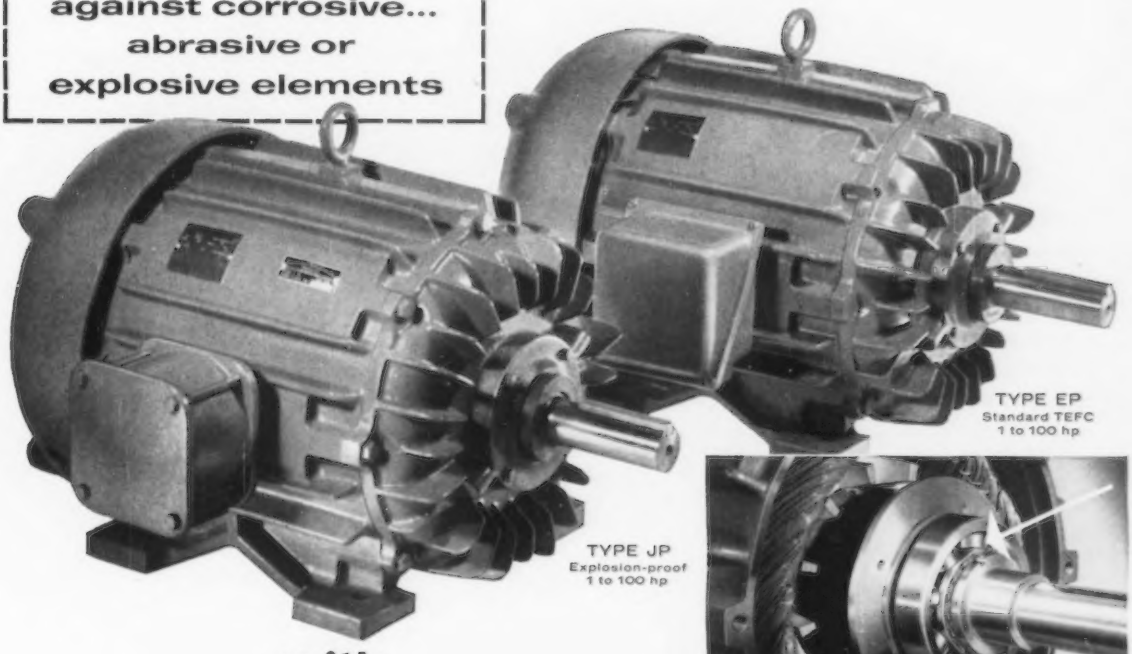
The attentive mechanics at Madison-Kipp invite you to clip this ad as a reminder to contact them for close cooperation on the momentous details of design when you next have die casting requirements.

kipp

MADISON-KIPP CORPORATION
206 Waubesa Street • Madison 10, Wis., U.S.A.

Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

YOU GET
EXTRA PROTECTION
against corrosive... abrasive or explosive elements



TYPE EP
Standard TEFC
1 to 100 hp

TYPE JP
Explosion-proof
1 to 100 hp

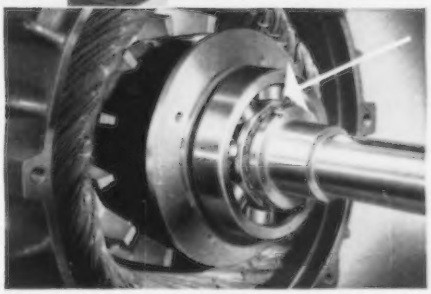
with

Wagner totally enclosed motors... protected for longer motor life

If you need motors that will keep production rates up . . . that will give the continuity of service that is so important to automation . . . that will operate with complete dependability under the most severe conditions—Wagner totally-enclosed motors are your soundest choice.

Type EP Motors offer protection against corrosion, dust, abrasives, fumes, steel chips or filings. Type JP is explosion proof as well—designed and approved for use in explosive atmospheres.

NEW NEMA FRAMES . . . These motors are built in the new NEMA Frame sizes from 182 through 445U, with ribs that add mechanical strength and increase the surface cooling area. Effective cooling system adds to motor life. Let your Wagner Sales Engineer show you how these protected motors can bring you savings on initial motor costs, maintenance costs and continuity of operation.



HEAVY DUTY BALL BEARINGS . . . The ball bearings used in these motors are of the highest quality, with more than ample capacity to provide long troublefree service under heavy loads.

BEARINGS CAN BE RELUBRICATED . . . Factory installation will last for many years under normal service, but openings are provided to permit relubrication that adds years to motor life under severe conditions.

SEALS KEEP BEARINGS CLEAN . . . Both ends of these motors have running shaft seals to keep the bearings clean. Bearing housings are effectively sealed to prevent escape of grease.

1 TO 100 HP—4 POLE, 60 CYCLE—
NEMA FRAMES 182 THROUGH 445U

Wagner Electric Corporation
6406 Plymouth Ave., St. Louis 14, Missouri.

WM58-5

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

Rolled split spacer tubes are produced in a wide variety of standard and special designs, in many lengths and diameters, of steel, brass and aluminum. They can be ball-indented for oil pockets, or made with oil holes or other special cutouts or seams.

FEDERAL-MOGUL DIVISION

Federal-Mogul-Bower Bearings, Inc., 11043 Shoemaker, Detroit 13, Michigan

Rolled, Split Bushings

Engine Bearings

Bimetal Bushings

Bearing-Surfaced Thrust Washers

FEDERAL Mogul

Since 1889

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ANNOUNCING THE SERVOTRAN!

a revolutionary new variable speed drive

Here's a remarkable new variable speed drive for 1/50 to ¼ hp. Called the Servotran, it can go from full speed forward to full speed backward in less than .05 second! The speed control shaft covers the full range with a movement of only 15 degrees in each direction. Control force required is only two or three ounces. Output torque is constant and efficiency is between 85 and 95%.

Range is infinitely variable from zero to full speed. Positive speed adjustment can be obtained by using an accurately calibrated dial. The output speed is so accurate that the Servotran may be used as an integrator in such applications as continuous material weighing or pricing systems.

The Servotran was developed by Humphrey, Inc., manufacturer of gyros and other electro-mechanical instruments for every major missile program.

There are hundreds of applications for this unique speed transmission. Use the coupon below to get more information on how you can use it.

A FEW OF HUNDREDS OF APPLICATIONS

Continuous material weighing systems • Automatic multiplying systems • Pressure regulated speed control • Remote speed control • Automatic winding or reeling systems • Power boost systems • Infinitely variable speed drives.

Humphrey Inc.
ELECTRO-MECHANICAL INSTRUMENTS

DEPT. P-38, 2805 CAÑON ST., SAN DIEGO 6, CALIFORNIA
Please send me more information
NAME _____
COMPANY _____
ADDRESS _____
CITY _____ STATE _____

(*Advertisement*)

Excellent Formability of Magnesium Inspires Simplified Designs

Deep drawn components, for example, replace multipart assemblies

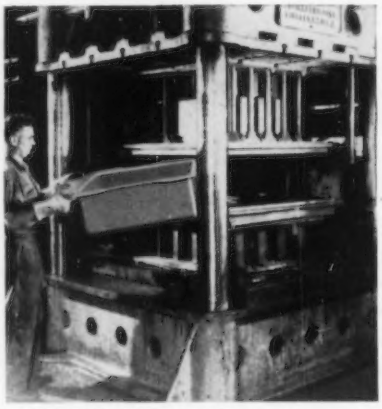
IN forming magnesium alloys, there's often more than one way to do the job. Matter of fact, the excellent shop characteristics of this remarkable metal permit it to be formed by almost every forming method known. The use of magnesium makes it possible to simplify complex designs that otherwise would require several separate parts and numerous production operations. Its high strength-to-weight ratio permits a choice of lighter design without loss of strength, or stronger design without weight penalty. Magnesium's hexagonal crystalline structure means excellent workability at elevated temperatures which offers the following advantages:

1. Deeper single draws than with other metals.
2. Reduced tooling costs.
3. Minimized springback.
4. Less wrinkling.
5. Better tolerance control by temperature adjustment.

These considerations, added to the fact that magnesium is the metal that's easiest to machine and fabricate, mean substantial cost savings in design and production.

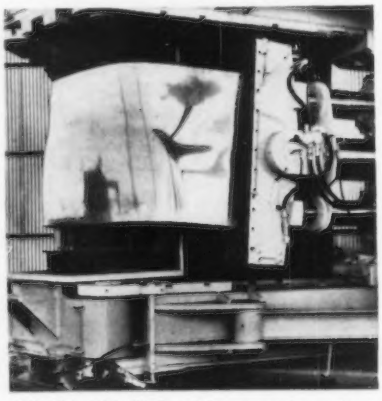
Here are a few of the forming methods that yield these advantages:

DEEP DRAWING AND PRESSING. Magnesium parts are made by both deep and shallow drawing or pressing. Magnesium sheet alloys in the annealed condition may be cold drawn with a reduction of 15 to 25 per cent. Hot drawing, however, increases the reduction up to almost 70 per cent. Deeper single stage draws can be made in magnesium (when heated) than in other metals.



LARGE DEEP DRAWN PARTS can be made in a single step with magnesium alloys.

STRETCH FORMING. This highly flexible method is used in shaping large area magnesium sheets. Jaws hold opposite edges in tension while a male block or punch stretches the metal beyond its elastic range. Stretching the entire work piece insures uniform pressure at all points of contact during forming. This results in even distribution of work hardening and the elimination of localized strains. Changes in cross sectional dimensions are more uniform than with other forming methods. Hot stretch forming results in a minimum of springback.



STRETCH FORMING with magnesium alloys provides uniform properties on large sections.

RUBBER FORMING. For relatively small quantities of shallow parts, this process can be put to good use. Both hot and cold forming can be done. Dies cost much less than for other methods and design changes are easy and inexpensive to make. The principle of rubber forming is simple. A pad of rubber powered by a ram forces the work blank to assume the contour of a die directly below it.

DROP HAMMER FORMING. This method is often used for asymmetrical shapes with shallow draws, or cases where special springback control is required. Drop hammer forming is not a precision method, hence close tolerances are not possible.

SPINNING. When a number of small parts are needed, spinning is often the most economical way to accomplish the job. However, as many as five thousand parts can sometimes be spun for less cost than when made by press forming. Spinning involves no dies, and the cost of chucks and spinning tools is relatively inexpensive.

EXTRUSION FORMABILITY. Production bending of extrusions is done on standard rolls, in mating dies, in stretch forming machines, or other specialized bending equipment. If the forming is severe, extrusions are formed hot. The bending of complex extrusions requires that bend radii be established for a given shape by the shop for its particular application.

FORMING MAGNESIUM, a 130-page handbook, covers all methods of forming discussed above, plus blanking and cutting, bending, dimpling, forging, hand forming, selection of alloys and assembly protection. Includes numerous tables on properties at temperatures, dimensions, etc. For your copy contact a Dow sales office or write THE DOW CHEMICAL COMPANY, Midland, Michigan, Dept. MA 1452V.

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protecting products the Caplug way
can save you hundreds $$ . . . for pennies spent

quick to put on...and quick to take off...fit tremendous variety of tubing, threaded fittings and machined parts

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take your pick from this big closure family
...10 standardized styles...over 500 sizes in stock

molded of flexible Polyethylene
... won't chip, break, shred or collapse

get a free handful of Caplugs like this
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tough enough to take abuse
...yet, most kind to threads and polished surfaces

CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
2205-9 Elmwood Ave., Buffalo 23, N. Y.

Mail a free assortment of Caplugs, literature and prices to us, without obligation.

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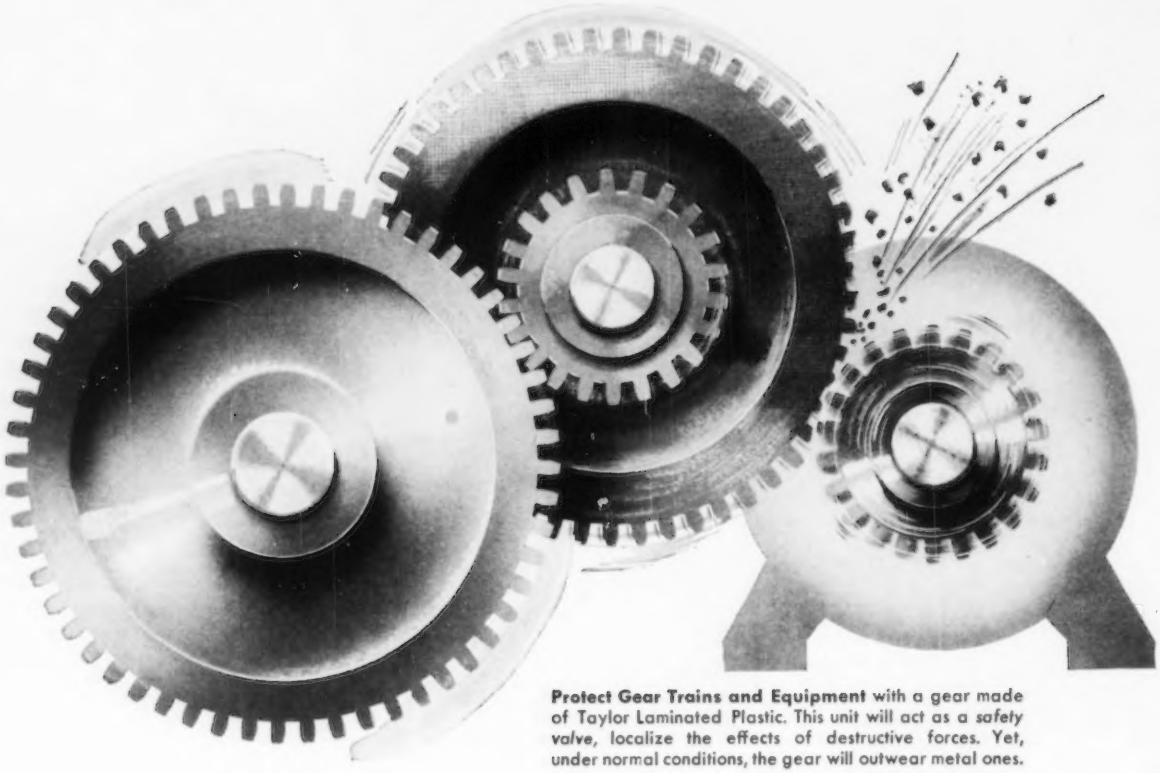


Protect Gear Trains and Equipment with a gear made of Taylor Laminated Plastic. This unit will act as a *safety valve*, localize the effects of destructive forces. Yet, under normal conditions, the gear will outwear metal ones.

Put a safety valve in your gear train

A gear made of Taylor Laminated Plastic Silent Gear Stock will localize damage due to destructive stresses, yet outwear metal under normal operating conditions

What gives when gears jam—the power train, the equipment they are in, or a single easy-to-replace gear? It can be the single gear when you install one made of Taylor Laminated Plastic Silent Gear Stock as a *safety valve*. This gear will localize the destructive forces and can even disintegrate—but the other gears in the train, and the equipment, will be fully protected. Yet it can outwear the metal ones.

Taylor Laminated Plastic Silent Gear Stock is made in several grades. Each has physical and mechanical properties that make it particularly adaptable to such application as gears, cams, pulleys, pinions, flat springs, and bearings.

Look into the advantages of Taylor Fibre Co. and its facilities for producing laminated plastics in mechanical, electrical and combination grades and parts fabricated from them. At your disposal will be engineering assistance and integrated operations at both plants—Norristown, Pa., and La Verne, Calif. Contact TAYLOR FIBRE CO., Norristown 39, Pa., for complete information.

PHYSICAL PROPERTIES

Taylor grade	Water Absorption 24 hr. immersion (% max.)		Specific Gravity	Cu. in. per lb.	Rockwell Hardness	Heat Resistance (max.)	
	1/8 in.	1/2 in.				Continuous use (°F)	Intermittent use (°F)
C	2.5	1.2	1.35	20.5	M-103	200-225	225-250
L	1.6	0.90	1.35	20.5	M-105	200-225	225-250
LLL	1.6	0.90	1.32	21.0	M-105	200-225	225-250

MECHANICAL PROPERTIES

Taylor grade	Flexural Strength Flatwise (psi min.)		Tensile Strength (psi min.)		Compressive Strength (psi min.)	Izod Impact Strength Edgewise (ft./in. notch min.)	
	Lengthwise	Crosswise	Lengthwise	Crosswise	Flatwise	Lengthwise	Crosswise
C	17,000	16,000	10,000	8,500	37,000	2.10	1.90
L	15,000	14,000	14,000	10,000	35,000	1.35	1.10
LLL	20,000	19,000	13,500	11,500	37,000	1.45	1.35

Typical Physical and Mechanical Properties of Taylor Laminated Plastics used in the fabrication of gears, cams, pinions, pulleys and bearings

TAYLOR
Laminated Plastics
Vulcanized Fibre

PHENOLIC-MELAMINE-SILICONE-EPOXY LAMINATES • COMBINATION LAMINATES • COPPER-CLAD LAMINATES • VULCANIZED FIBRE

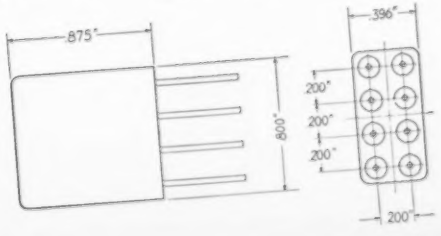
These could be the
MOST IMPORTANT RELAY "SPECS"
you ever read!

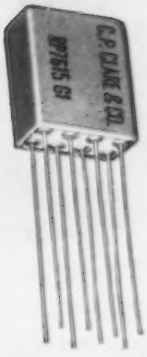
• Here is a relay admirably geared to the needs of today's advanced circuit designers. Hermetically sealed—no bigger than a postage stamp —stalwart to withstand extremes of temperature, heavy shock and severe vibration—yet fast and more than moderately sensitive.

CLARE *Type F* RELAY

SPECIFICATIONS

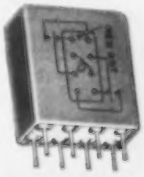
Ambient Temperature	—65° C to +125° C.
Shock	50 Gs for 11 milliseconds.
Vibration	5-75 cps at maximum excursion of ⅛-inch, 75-2000 cps at 20 Gs acceleration.
Dielectric Strength	Sea level—1000 volts rms between terminals and frame, and between adjacent circuits; 750 volts rms between contacts of a set. At 80,000 ft., 350 volts rms.
Insulation Resistance	1000 megohms minimum at 125° C.
Coils	Coils up to 10,000 ohms available for a wide range of voltages or currents.
Nominal Operating Power	250 milliwatts.
Pickup Time	3.5 milliseconds nominal.
Dropout Time	1.5 milliseconds nominal.
Contact Arrangement	2 pdt (2 form C).
Contact Rating	3 amps resistive at 28 volts d-c or 115 volts a-c; also for low-level applications.
Contact Resistance	0.050 ohm maximum.
Contact Life	500,000 operations minimum at 2 amps; 100,000 operations minimum at 3 amps.
Enclosure	Hermetically sealed, filled with dry nitrogen at 1 atmosphere pressure.
Mounting	All popular mounting arrangements available.
Terminals	Printed circuit; solder; plug-in (matching socket available). Variations of printed-circuit terminal length on 1/10-inch grid spacing available.
Weight	17 grams.
Military Specifications	MIL-R-25018; MIL-R-5757C, except as to contact overload.





Designers of printed circuit layouts will note terminal arrangement is nicely suited to 1/10 inch grid spacing.

Contacts, rated at 3 amperes, are proven also for low-energy level circuit applications.



All popular mounting arrangements are available.

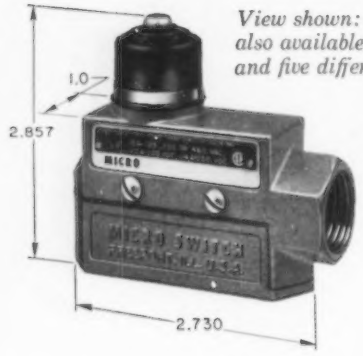
For complete information send for Bulletin 124. Address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable Address: Clarelay

CLARE RELAYS

FIRST in the industrial field

MICRO SWITCH Precision Switches

NEW! . . . A new housing for the widely used "E" and "V" series provides Easier Installation . . . a Better Seal . . . and Better Insulation



View shown: side mounting; also available with bottom mounting and five different actuator designs.

This new housing replaces the one formerly used in the "E" and "V" Series and is known as the "E6" and "V6" Series. The new series is interchangeable with the old series.

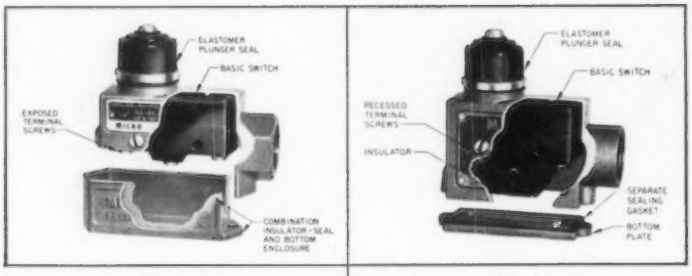
The new "E6" and "V6" have these outstanding advantages:

Easier Installation. Terminal screws now project from top portion of housing instead of being recessed in a cavity, thereby making easier installation.

Improved Insulation. A one-piece moulded neoprene insulator-seal, cemented into lower portion of housing replaces the separate, wrap-around Fiberglas insulator and separate gasket.

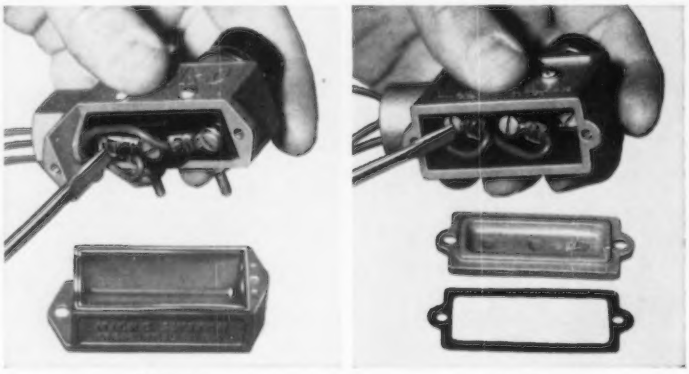
Rugged–Heavier Walls. The new, two piece housing has heavier walls—a hex-shaped conduit hub instead of round. A much cleaner, stronger design.

Interchangeable with old series. Dimensionally the same as old series—same mounting holes, same width, height and depth. Compact—fewer parts.



NEW OLD

Compare these two cut-away views. Note how terminal screws in the new "E6" Series project from the bottom of the top portion of the housing; how the insulator and seal are one moulded neoprene piece, cemented into the bottom part of the housing.



NEW OLD

The new series design can be installed in jig-time. No deep cavity in which to fumble with a screw-driver, no fold-in insulator, no jiggling with a separate sealing gasket.

For complete details of this new series write for Data Sheet No. 145.

The two word name "MICRO SWITCH" is NOT a generic term. It is the name of a division of Minneapolis-Honeywell Regulator Company.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

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First in Precision Switching

MOLY NEWS

CLIMAX MOLYBDENUM, 500 FIFTH AVENUE, NEW YORK 36, N. Y.

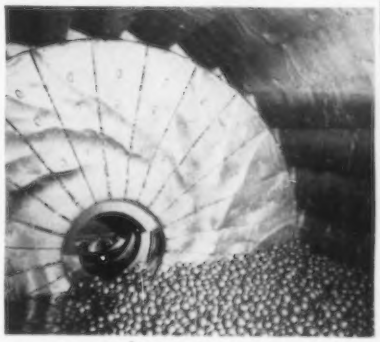
Chrome-Moly Steels Prove Ability To Resist Wear and Abrasion, Cut Costs

Can be Adapted to a Wide Range of Uses

To offset rising equipment and maintenance costs, the savings possible with wear-resistant alloy steels are receiving increasingly wide attention, in a growing number of industries.

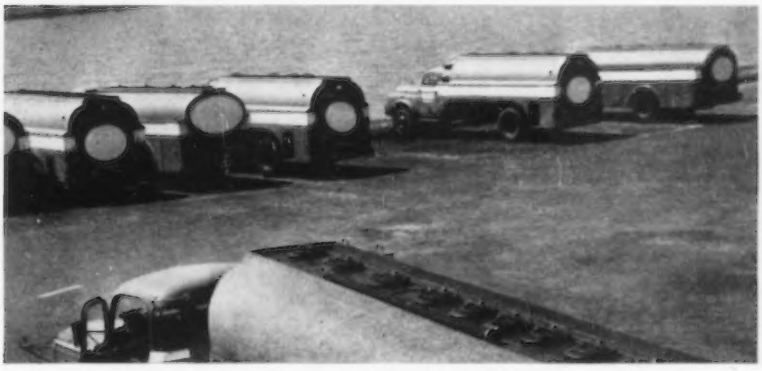
Two types of "Chrome-Moly" steels show exceptional resistance to abrasion and wear under toughest conditions. Both have substantially cut liner costs and shutdown time in grinding mills. Both are suitable for a variety of other industrial applications because they combine wear resistance, favorable first cost, freedom from premature failure by breakage or spalling, resistance to flow in service, consistently uniform performance and adaptability to specific designs.

The two types are Pearlitic (250-450 BHN) and Martensitic (450-700 BHN). Carbon and alloy contents and heat treatments of both types can be varied to suit specific applications.



Note that the spiral wear pattern is clockwise, even though the mill's rotation is counter-clockwise. Type 2 Martensitic steel is used here.

For an article on the use of Chrome-Moly steels, send for "How to Select Chrome-Moly Steels for Ball and Rod Mill Liners" by T. E. Norman, reprinted from Engineering and Mining Journal. Circle #1 on the coupon.



New Use For Super-Strength Structural Steels

Today, gasoline trailer tanks are built of super-strength structural steels for a good reason. The steels have high strength/weight ratios. This factor enables builders to design tanks that carry greater payloads and still meet legal gross weight limits. And the extra capacity pays for the higher trailer cost in a few months!

This use is only one of countless possibilities for utilizing the steels' minimum yield strengths of 55,000 to 150,000 psi . . . and their many other desirable properties. *For more information, including tradenames and compositions, ask for "Super-Strength Structural Steels." Circle #2.*

Special Steels Solve Hydrogen Sulphide Problem

Hydrogen sulphide in France's Lacq natural gas field brought up a metallurgical problem: the need for tubing meeting the N-80 strength requirements but with better resistance to sulphide stress corrosion than the conventional N-80 grade. Two such steels have been developed. One contains chromium, aluminum and molybdenum; the other contains chromium, molybdenum and vanadium.

For articles discussing both steels, send for "A Special N-80 Steel Tubing . . . " by Cauchois, Didier and Herzog, reprinted from *Corrosion*, and "Comments on new French N-80 Steels" published by Climax. *Circle #3.*

Vanadium in Low-Alloy, High-Temperature Steels

Molybdenum is a must in low-alloy, high-temperature steels. However, recent tests at the U.S. Naval Research Laboratory point up the role of Vanadium in such steels, and show the effect of variations in composition and treatment. Addition of Vanadium results in a better high-temperature alloy, but getting the improvement requires higher normalizing temperatures.

The advantages and limitations are described in an *Iron Age article*, "Higher Vanadium Improves Hot Strength of Low Alloy Steel," by Paul Shahinian and J. R. Lane. *For reprints, circle #4.*

New Cleaner Removes Surface Oxides From Moly Metal

A practical, low-temperature method of cleaning molybdenum has recently been developed. It is especially suitable for removing surface oxides prior to welding. The process involves two chemical baths: one at 150-180°F, the other at room temperature. *Digested from "Ryan Devises Molybdenum Cleaner," Ryan Aeronautical Company. For reprints, circle #5.*

Sums Up Moly's Resistance to Corrosion

A new paper, "Corrosion Resistance of Molybdenum and Molybdenum-Base Alloys," based on published literature, summarizes moly's resistance to a number of corrosive media. It also lists the reference articles. For a copy of this paper, *circle #6.*

Molybdenum Improves Corrosion Resistance of Stainless Steels

Translated excerpts from two French articles discussing how moly improves the corrosion resistance of austenitic and austenitic-ferritic stainless steels are now available. *Circle #7.*

Climax Molybdenum, Dept. 61
500 Fifth Avenue, New York 36, N. Y.
I'd like more information on:
1 2 3 4 5 6 7

Name_____

Company_____

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City_____ State_____

The Year Advertising Helped

This editorial message was first published by McGraw-Hill two years ago. It describes advertising's dramatic contribution to the American economy during 1954. The theme of the editorial—that advertising can help promote economic stability by stimulating sales at a crucial time—is even more pertinent today.

As our economy grows, it is constantly changing. The conditions business faces today are not the same in every respect as those it faced in 1954. But business again has the opportunity, through advertising and other selling efforts, to help sustain a high level of economic activity. At the same time, it will be building markets for the period of renewed expansion that is sure to follow.

This editorial is reprinted exactly as it appeared in 1956 except for minor editorial changes to bring it up to date. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or parts of the text.

Donald C. McGraw

PRESIDENT
McGraw-Hill Publishing Company, Inc.

IN 1954 we had a business recession in the United States. Sales fell about 4% during the year. If management had followed the historic pattern of business ups and downs, advertising volume would have fallen much further.

But in 1954 the volume of advertising did not fall. It increased over 5%, and expenditures in all major advertising media rose. Every effort was made to stimulate sales when sales were needed to sustain prosperity.

This was something entirely new under the sun. It had a powerful influence in making the recession of 1953-54 one of the mildest on record. It helped greatly to speed business on to the record-breaking levels it attained in the years 1955-57.

There are several reasons why America's business management attacked this decline in sales with more advertising. One of them grew out of the greatly strengthened position of the American consuming market. Consumers' income after taxes has been rising an average of over $10 billion a year since 1946, and this rising income is more widely distributed than ever before. Furthermore, consumers had piled up reserves of about $200 billion in cash or its equivalent. These reserves offered a new and powerful inducement to increased selling and advertising effort even in the face of a possible decline in consumer income. (At the end of 1957, consumer reserves were $225 billion.)

Taking the Longer View

However, the principal reason why a sales decline was attacked with increased advertising is management's new-found conviction that good advertising is essentially an investment in the development of a market. Successful development requires sustained investment. The inclination of business management to take this longer view is, of course, motivated

McGraw-Hill PUBLISHING COMPANY,

ABP HEADQUARTERS FOR

Kill a Business Recession

by the fact that the American market, with over 3 million consumers being added annually, is growing at a prodigious rate.

Ten years ago only a handful of companies had plans for investment in new producing facilities extending beyond the current year. Today almost all leading companies have investment programs running some years ahead. And keeping pace with these long-range investment plans has been the development of sales and advertising programs to reach tomorrow's greatly expanded markets.

Advertising's Key Role

This crucial role of advertising in providing driving power for our economy is gaining greater recognition every day. In his book, "People of Plenty," Professor David M. Potter of Yale University remarked: "Advertising is not badly needed in an economy of scarcity, because total demand is usually equal to or in excess of total supply, and every producer can normally sell as much as he produces. It is when potential supply outstrips demand—that is, when abundance prevails—that advertising begins to fulfill a really essential economic function."

Today abundance so completely prevails in the United States that it has been conservatively estimated that as much as a third of everything offered for sale falls in the realm of "optional consumption." That is, consumers can "take it or leave it" without any immediate personal inconvenience. But if they decide to "leave it," a terrific economic depression will not be far behind. In such circumstances, advertising—in which, in all of its forms, we are now investing over $10 billion annually—clearly is of crucial importance to our continued prosperity.

In performing its key role in past years, American advertising never realized its full potential. It successfully promoted sales. But it never was called upon to promote an overall economic stability as a direct outgrowth of increased sales.

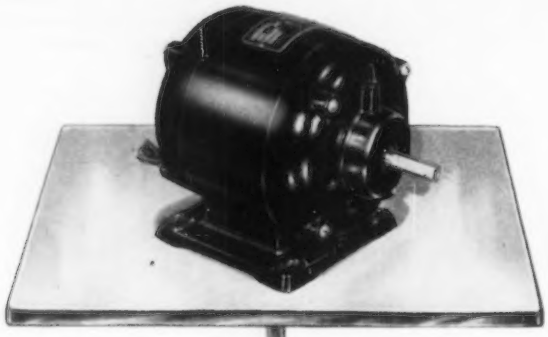
By successfully promoting both sales and economic stability, as it did in 1954, advertising surely has added new strength to the American economy. It has also added a great new and constructive dimension to advertising itself.

One of the surest means of expanding your sales volume in today's industrial markets is through dominant advertising in the publications directly serving your major customers and prospects.

McGraw-Hill's business and technical publications can give you quick access to the men who initiate, specify and approve the purchases of industrial products and services. Because all are leaders in their respective fields, you are assured a maximum return on your advertising investment when you *concentrate* in the McGraw-Hill publications serving your most important markets.

INCORPORATED · 330 West 42nd St., New York 36, N. Y.

BUSINESS INFORMATION



BODINE MOTORS
In Leading Products . . .

Sanborn Oscillographic Recording Instruments

The element of time is very important in recording electrical and physical properties . . . and this is one of the reasons that Bodine synchronous motors are used to power Sanborn Oscillographic Recording Instruments. These units can operate at nine different paper chart speeds, and the motor that powers the chart moving mechanism must respond quickly, and be capable of operating at any of the pre-determined constant speeds. Over the years Bodine motors have met Sanborn's requirements for constant speed, minimum noise, uniform performance and long life.

Esterline-Angus Recorders

To provide a complete record of what happens during a power failure, Esterline-Angus developed an external motor attachment for their recorders. When a power outage occurs, the Bodine motor driven attachment takes over and increases chart speed to ¾" per second to record these split-second occurrences.

The ability to start fast, accurately maintain the necessary speed and operate quietly are the main motor requirements. It was also necessary that both AC and DC motors have the same mounting dimensions. Esterline-Angus found that Bodine motors made their external drive less cumbersome.

BODINE ELECTRIC CO.
2260 W. OHIO ST., CHICAGO 12

BODINE
fractional / horsepower
MOTORS

BODINE ...the power behind the leading products

12 to 16 week delivery on fractional horsepower motors
265 different stock types and sizes ready for fast shipment!

How to make motors last longer

Proper maintenance is your best insurance for obtaining good service and long life from fractional hp electric motors.

Inspect your motors regularly. Twice a year inspect bearings, cutouts and other wearing parts. Be sure dirt and dust does not interfere with ventilation, or clog moving parts.

Check load condition. Additional friction sometimes develops gradually in the machine your motor must drive, and thus imposes an overload. Watch motor temperature. Protect your motors with properly rated fuses or overload cutouts.

Replace worn brushes. Inspect brushes regularly. Whenever a brush is removed for inspection, be sure it is replaced in same axial position and NOT turned around in the brush holder. Otherwise excessive sparking and power loss will result.

Keep commutators clean. Use clean, dry cloth or one moistened with carbon tetrachloride to remove dust and oil. If necessary use No. 0000 or finer sandpaper.

Watch future Bodine ads for additional maintenance suggestions.

Free subscription to "The Motorgram"

Ask that your name be added to the circulation list to receive "The Motorgram." A bi-monthly publication, it discusses the design and application of fractional horsepower motors.

PERSPECTIVES

in design and development . . .

Recognition and the Engineer

Hand in hand with the recognition-of-engineers problem is another—the problem of finding the most acceptable method of testing engineers for the purpose of registration. Both subjects were discussed in the Dec. 9, 1957 editorial by E. J. Tangerman, editor of *Product Engineering*. The editorial drew several letters. One, from Benjamin F. Harrison, Jr., Oak Park, Mich., said the usual examinations were not practical, didn't prove a thing, "except that a person has retained some of the mathematical theory that he studied during his college years."

Mr. Harrison's letter, published in our Jan. 20, 1958 issue, offered three requirements for registration: (1) a minimum of 10 years' experience; (2) recommendation by five registered engineers who can testify to the applicant's experience; (3) solution of a complete, original design problem to be selected by the state board of examiners. The problem would be given in the man's specialized field, and his license would be made to read accordingly, such as "Mechanical Engineer—Machine Design."

Affirming he was not against registration, Mr. Harrison said, "A person can be on a drafting board, pass his examination and then go right back to doing the same work he was doing before he went to all the trouble to bone up for the test. The license has not advanced his proficiency. His employer probably knows more about his capabilities than the state board does. When he has demonstrated his ability, the company is willing to rely upon his judgment and give him the title, 'Engineer.' Who, then, can say he is not an engineer? He does the work of an engineer; his employer, his friends and his family recognize his abilities and, in most cases, this is sufficient for the man. There is, however, a prejudice among those who have registered and feel that everyone else should have to take the same examinations that they did."

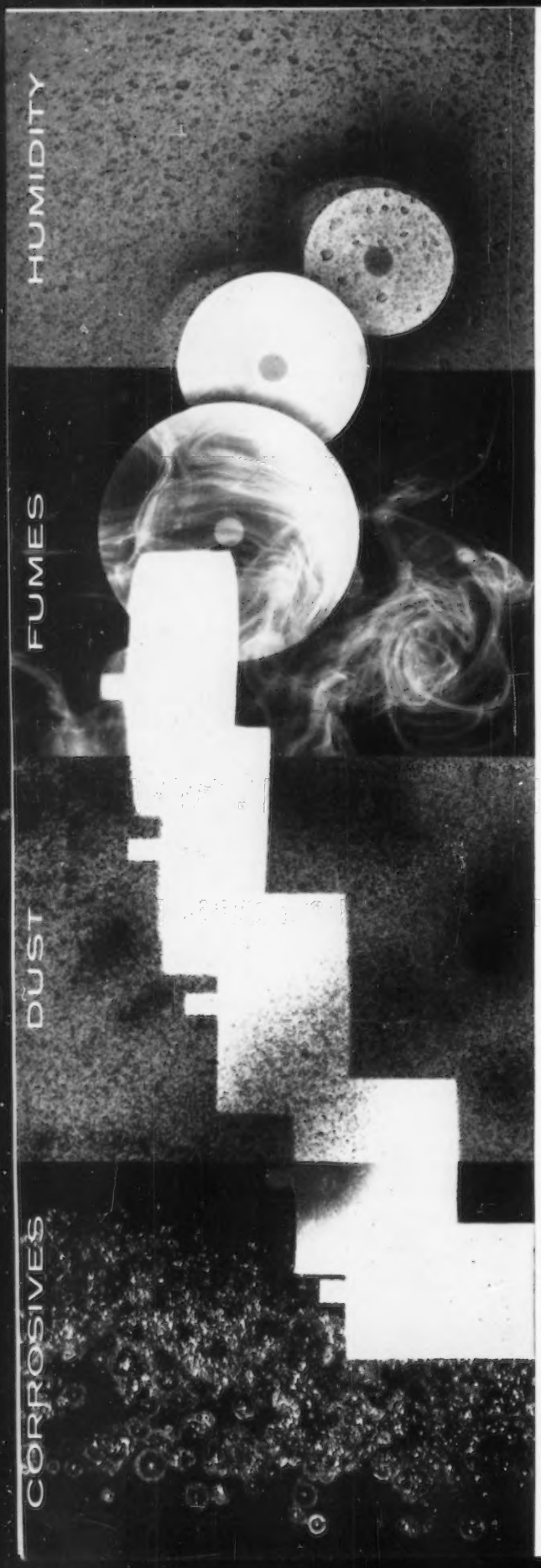
Unanimous Disagreement

Mr. Harrison's letter drew several letters—all very much opposed to his practical solution to the problem. For example, C. C. Perry, a consulting engineer of Royal Oak, Mich., says, "The basic reasons for not registering go considerably deeper than just the feeling that the examination may not be practical—since most engineers know about the examination only what they have learned by hearsay. Other reasons for not taking the examination are: fear of failing to pass the first time; reluctance to place themselves in a competitive position of being tested and rated; unwillingness to review long-forgotten and badly needed fundamentals; general lethargy; apathy; lack of intellectual aggressiveness, common to engineers; and the attitude that becoming a P.E. is of no value if it will not bring a new title and an immediate pay raise."

Just a Practical Technician

Mr. Perry continues, "Mr. Harrison would seemingly have us tailor our registration examinations so that they could be passed by the typical engineer who has been in industry as a designer for 10 years or more, who has almost completely lost what command he may once have had of engineering fundamentals, whose knowledge and interests are limited only to his own company's product (or more frequently, one facet of that product), who has not read an advance technical book for years, whose designs are based upon an unoriginal but usually safe combina-

(Continued on page 63)



Need a motor impervious to destructive environment?

Call Jack & Heintz—America's leading specialist in *Customized* motors, 1/8 to 3 hp (1/3 to 15 hp in submersible motors). We'll gladly devote as much time as it takes to design a motor that's *impervious* to humidity, dust, fumes, corrosive liquids or altitude. We'll give you a motor that electrically, mechanically and physically fits your product and its environment perfectly.

Customizing electric motors to meet the specific requirements of original equipment manufacturers is *our business*. Because we're organized that way, costs are reasonable.

In addition to customizing for environment, we can increase torque, stretch a motor tall, squat it flat, or design-in special ambient temperature rating. We'll make a motor cool, flush, submersible, or give it a special finish. *You name it!*

So go ahead freely! Design your product to do its job. We'll fit a motor to it that will make your product perform the way you want it to . . . look as good as it should . . . last as long as you say it will . . . and sell faster because of it.

FREE! Write for this 24-page booklet. It explains when to specify *Customized* motors, shows examples of design variations, illustrates case histories of *Customized* motors for actual products. Write: Jack & Heintz, Inc., 17627 Broadway, Cleveland 1, Ohio.

JACK & HEINTZ, Inc.
CUSTOMIZED ELECTRIC MOTORS

tion of intuition, handbook data, and earlier or competitive models of the same product, and who undoubtedly considers himself a 'practical' engineer. Such a man is a practical technician, not an engineer, and any examination and/or registration procedure should be so labeled. An engineer with 10 years' experience is often one who has been making the same mistakes twice as long as an engineer with 5 years' experience."

College Profs Conduct the Exams

T. F. Peterson, a professional engineer of Grand Forks, N. D., feels that the testing problem of "book learning" vs "practical" knowledge has arisen because we have relied upon our university professors to conduct and supervise the examinations. "This is entirely practical", he says since examinations are a part of their regular work. They are (supposedly) capable of devising and administering examinations covering their own field of engineering. However, it is entirely natural that these examinations would be limited to the 'book' which they teach.

"I have taken a bar examination and recently saw the examination given in medicine for my own state. Neither of these was as specialized as the examinations for registration as an engineer. In both Law and Medicine all candidates wrote the same examination. There was no differentiation between corporate law and criminal law. There was no differentiation between Osteology and Gynecology. But when I have written an engineering examination, Mechanical, Civil, Electrical, Petroleum, etc., were separated and given different examinations by different examiners.

"While few will disagree with the premise that specialization is needed before a man can achieve much, I am doubtful that we engineers will ever gain professional recognition so long as we attempt that specialization before we have mastered the fundamentals of our practice. I believe that if we insist upon this early specialization (the second year of most engineering curricula) we can only attain the level of 'technically trained boors' attributed to us by many of our brethren of the Liberal Arts."

Ideas Have Labor Union Concept

The approach taken by Mr. Harrison was also described as being similar to the work limits concept of organized labor rather than that of professional engineering. "Why stop here?" asks H. E. Nimke, a professional engineer from Brooklyn, N. Y. "Let's go a step further to grant separate and specific licenses to the adders, multipliers, subtractors and dividers.

"Mr. Harrison has lost sight of the only valid reason for registration: protection of the public against technical incompetence. In this sense, registration is not the decoration or the reward for 'quality' that Mr. Harrison seeks to make it. At present, registration does not achieve its aim of public protection only to the extent that the unregistered can bear the title of 'Engineer.'

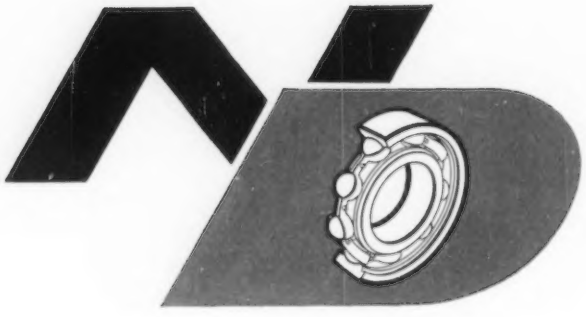
Plow a Broader Technical Field

What is the value of the present licensing method? According to Mr. Nimke: "It is the fact that the license has proven his ability to plow a broader technical field, that he has a grasp of technical concepts beyond that which he would require as a specialist. This may not make him a better specialist per se, but it will make him a better 'engineer', more adaptable, self-sufficient, technically reliable, competent and generally more valuable either in practice in a field, or as a candidate for specialization. The objectives of professionalism, which we all hold so important, cannot be attained by debasing the requirements for registration to the limits of a variety of specialties, specific subordinate rectangles in the general table of our technical organization." —Paul Anderson

NEW DEPARTURE

NEW DEPARTURE

NEW DEPARTURE



Symbol of a Reputation

. . . a reputation for integrity, for quality and service . . . for advanced creative engineering achieved by New Department in over half a century of precision ball bearing manufacture.

You'll find this emblem is also symbolic of our determination to continue, in the fullest measure, all those factors which have built that reputation. It is a visual pledge of this resolution to all our customers, present and future.

turning point of modern industry

1908–1958 GM FORWARD FROM FIFTY

NEW DEPARTURE

DIVISION OF GENERAL MOTORS—BRISTOL, CONN.

Product Engineering

March 17, 1958

For want of a nail . . .

Several scientists have suggested recently that we abandon such titles as the Atomic Age, Alloy Age and Science Age for our current era and that we substitute "Age of Acceleration." They point out that what keeps throwing us is the change of pace.

Today's products are getting smaller and smaller . . . or bigger and bigger . . . or faster and faster . . . on an accelerating scale. And some up-to-now-perfectly reliable component is suddenly too small for structural strength or acceleration forces, or is asked to handle too much overload. The part you weren't looking at—never even worried about—fails, to the dismay of an entire company—possibly an entire nation Extrapolation caught up with it.

Just such extrapolaton carried too far accounts for the failures of the *Vanguard*. First, a little switch, next a wiring defect—and minor malfunctions knock down $20 million worth of rockets.

Designers, civilian and military, are understandably reticent. On this one subject, the Pentagon has little to say. But we did find one lab expert who was willing to talk. Here's what he says:

"Often, failures are the result of wires coming undone, soldered joints breaking, hydraulic connectors leaking—the same little failures we had ten years ago. In some cases, nothing better can be found to do the job. For example, the simple reed vibrator has been improved upon, but it still has a high degree of failure. Next in line are relays, switches, potentiometers and their hydraulic and pneumatic equivalents; static-control devices offer promise but involve a different design technique. Vacuum tubes have been replaced by transistors, themselves subject to acceleration stresses and thermal transients. Rotating hydraulic-electric parts have been a big bogey. About three dozen components developed for this field are known to have failed; at least six companies have gone out of business—they could not make the product meet the specs.

"The trouble is amplified because parts have to be made to ever-finer tolerances. The component or subassembly contractor must have his part made in half the time a missile maker has to produce the missile—with no extensions. In these days of off-again, on-again projects, no company gets an unlimited time opportunity—funds may be cut off any time.

"Actually, most missile failures are caused by parts failures resulting from a lack of plain, ordinary engineering debugging."

Good design could solve many of these problems, but there just isn't time. And public clamor for a new "first" works against the designer. So he tries to get by with the best he has available. That sends a missile into the sea, new-model cars into the repair shop, ruins sales on an automatic washer.

It's still the little things that count—the little things that yield only to time. George Herbert said it three hundred years ago:

"FOR WANT OF A NAIL, THE SHOE WAS LOST;
FOR WANT OF A SHOE, THE HORSE WAS LOST;
FOR WANT OF A HORSE, THE RIDER WAS LOST."

K. Langeman

Fabrication is a problem . . . with most of these metals. But vanadium (shown in this Electromet photo), columbium and indium can be cold-rolled without serious difficulty.

willing and able . . .

EXOTIC METALS Seek Employment

For unusual jobs . . . for special structural and electrical problems, consider the more or less "rare" metals. Many have valuable, (though tantalizing), properties. Here are nine such metals ready to be put to work.

ANNESTA R. GARDNER
Associate Editor

Beyond the Big 3—iron, aluminum, and copper—stands a squadron of metals ready to do special jobs and solve special problems. Most are found only as small-quantity impurities in ores of more common metals. None is cheap. Many are hard to work and a few are dangerous to handle. But all are worth knowing, and most are in good supply right now—result of increased demand for their "parent" metals and improved processing techniques. Described here are nine of these—gallium, indium, bismuth, beryllium, chromium, vanadium, hafnium, columbium and rhenium. They range in weight from the bottom to the top of the scale. (Beryllium is the third lightest of all metals; bismuth is almost as heavy as lead.) One—gallium—is a liquid almost at room temperature. Another—rhenium—stands temperatures well over 5000 F. Yet they have many things in common.

All are "rare" compared with iron, aluminum, and even titanium. Most are hard to work unless in high-purity form. Some are not very ductile even then.

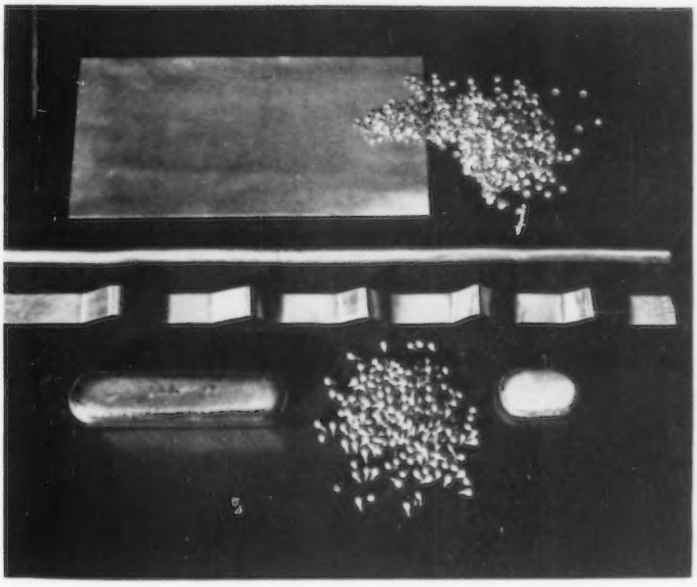
Still, as jet engines, nuclear energy, and electronic systems-of-the-future pose increasingly stringent demands, so-called "exotic" metals like these, offering unusual properties, rate close attention.

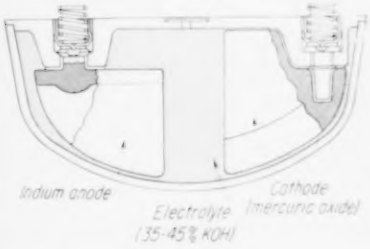
The text below highlights their special abilities and limitations, and the chart on p. 68 gives chemical and physical properties, availability, and recent prices. Because most of these metals are "new," many of their properties have not yet been pinned down with finality. The figures given here should therefore be considered simply as a guide for screening, and a jump-off point for further research.

GALLIUM

Unusual ability to "wet" other materials, and an unusually low melting point spark interest in gallium. But its price is high.

Gallium is a fascinating metal—and an exasperating one. Produced as a byproduct of aluminum and zinc mining, it resembles zinc in softness and aluminum in silvery appearance. It remains molten over an unusually





Indium is soft . . .
malleable, and easy to work; can readily be made into wire and ribbon. Pellets shown in Indium Corp. photo are used for transistors. Above, an indium battery is diagrammed. It is a long-lasting cell that can be made smaller than a penny.

broad temperature range: melts at 85 F, yet does not boil until past 3660 F. It has a unique ability to "wet" other materials.

Gallium can serve to reduce the temperature of low-melting alloys. Even fractional percentages will drop the eutectic point of indium-tin alloys 20F or more. Gallium is being investigated for semiconductor applications, and it has been suggested as a heat-exchange medium. It might take the place of mercury in high-temperature thermometers and liquid manometers. But, at $1350 a lb, most users are satisfied with the standard material.

INDIUM

Soft, easy to work, and easy to join to other metals, indium has been finding applications in bearings, storage batteries, and transistors and other electronic devices.

Indium may well be called the Cinderella metal. A few years ago, most engineers would have found it hardly worth intensive study. It was used in solders and low-temperature alloys, and to plate silver, cadmium, and lead bearings. But, at prices ranging from $27 to $72 a lb, applications for the pure metal were few and far between. Now, new electrical and electronic developments are changing the picture, and indium seems headed for widespread industrial use.

Indium is diamagnetic; resists corrosion by air, water, and alkaline metals; alloys readily with other metals; forms several semiconducting compounds (indium arsenide and antimonide, for instance). It is easy to fabricate and, like gallium, has the ability to stick to other metals. This last property brought indium its biggest current job: in germanium transistors. Germanium can't be soldered. Indium is not only solderable, but will adhere to germanium, and has the ability to modify its electronic properties. Result: each transistor has two or more tiny indium pellets for attaching leads to the semiconductor body.

An even newer and extremely promising application is in miniature storage batteries. About two years ago, Elgin National Watch Co. introduced its indium-anode "microcell" for electronic wrist watches and other applications. Says Elgin: indium anodes are so successful in eliminating leakage and gassing that the battery will last for years, and it can be housed in a thin plastic case occupying only a fraction of the volume normally required. Work on indium-anode batteries is continuing—and they look better all the time.

BISMUTH

Most diamagnetic of all metals, bismuth might be usable in voltage and current-regulation devices and in instruments for measuring magnetic fields. Biggest job now is in low-melting metals and solders.

Like indium, bismuth is valued for its low melting alloys. Many solders and low-melting metals—Cerro de Pasco's Cerrobend, for instance—are 50% bismuth, or more. But this metal has many interesting characteristics and shows possibilities for electronic, nuclear and electrical application.

Several electronic research laboratories are investigating bismuth, along with tellurium, selenium, antimony and similar metals for such direct heat-to-energy conversion devices as the "electronic refrigerator."

In the atomic energy field, bismuth's most likely career is as a carrier for uranium "fuel" in liquid metal reactors. (It has also been considered as a heat exchange medium; but here, other metals like sodium seem more suitable.)

In pure, "ductile," form, bismuth has outstanding electrical properties. Because it is diamagnetic, and responds sharply (by an increase in resistance) when placed in a magnetic field, it has been suggested for voltage-control instruments for radio and television, X-ray, electronic calculators and the like. Unfortunately,

COMPARISON, HIGH-PURITY PROPERTIES OF 17 RARE AND COMMON METALS

Name	Atomic No.	Density, lb/cu in.	Melting Point, F	Modulus of Elasticity $\times 10^6$, psi	Ultimate Tensile Strength, psi	Yield Strength, psi	Elongation, % in 2 in.	Electrical Resistivity at 20 C, microhm/cm	Lin. Coeff. of Exp. at 70 F $\times 10^{-6}$	Thermal Conductivity, cal/sq cm/sec/°C/cm	Price, $/lb	Relative Abundance (copper = 100)
BERYLLIUM	4	0.07	2345	44	35,000 to 95,000	30,000 to 45,000	2 to 20	4	7.1	0.385	47 to 75	8.6
MAGNESIUM	12	0.06	1200	6.5	12,000 to 37,000	20,000 to 30,000	10 to 20	4.6	14.4	0.376	0.37	30,000
ALUMINUM	13	0.10	1220	10.6	20,000 to 70,000	14,000 to 60,000	30	4.5	13.2	0.48 to 1.01	0.26	110,000
TITANIUM	22	0.17	3074	15.5	50,000 to 80,000	40,000 to 70,000	20 to 60	47.8	5.2	0.41	6 to 11	6500
VANADIUM	23	0.22	3452	20	55,000 to 75,000	40,000 to 65,000	16 to 33	24.8	5.0	0.074 to 0.088	79 to 80	300
CHROMIUM	24	0.26	3410	42	80,000	52,000	0 to 48	13.0	3.5	0.16	1.30 to 5.50	290
COPPER	29	0.32	1980	16	32,000	10,000	50	1.7	9.4	0.858 to 1.097	0.25	100
GALLIUM	31	0.22	85	....	.....	.....	.....	56.8	10	0.07 to 0.09	1362	21
ZIRCONIUM	40	0.235	3380	11	49,000	29,000	18 to 31	45	5.0	0.4	20 to 35	250
COLUMBIUM (NIOBIUM)	41	0.31	4380	12.4	50,000	24,000	40	14.2	4.0	0.13	55 to 85	34
MOLYBDENUM	42	0.37	4750	46	65,000 to 175,000	50,000 to 150,000	1 to 15	5.17	3.0	0.346	6 to 25	21
INDIUM	49	0.26	314	1.6	515	.....	41	9	18	0.057	35	0.1
HAFNIUM	72	0.47	3865	20	65,000 to 78,000	30,000 to 65,000	22	32.4	3.4	0.03	50 to 100	7.6
TANTALUM	73	0.60	5425	27	50,000 to 150,000	39,000	40	12.4	3.6	0.13	50 to 60	3
TUNGSTEN	74	0.70	6150	50	70,000 to 300,000	.....	0	5.5	2.2	0.31	8	92
RHENIUM	75	0.76	5740	67	170,000 to 320,000	130,000 to 300,000	2 to 25	21.6	3.4	0.17	700 to 1100	0.001
BISMUTH	83	0.35	520	4.6	5,000	1,260	.....	116	7.5	0.02 to 0.04	2.25	0.3

the purest bismuth is brittle. One company–Fitzpatrick Electric Supply, Muskegon, Mich.–is producing commercial bismuth wire and strip, and has made film 8,000 and 20,000 angstrom units thick; but no one seems able to produce a satisfactory sheet.

BERYLLIUM

Extremely light weight and unusual nuclear properties make this metal important, but it has some serious drawbacks.

If beryllium were not one of the lightest elements, with an extremely high strength-weight ratio, rigidity, good heat resistance, and unusual nuclear properties, it wouldn't have much of a future. It's toxic in some forms, brittle, expensive, and of questionable availability.

But the atomic energy program certainly needs it (it's an excellent moderator and reflector for atomic radiation), and the Air Force looks on it as a white hope for jet aircraft and missiles of the future.

Both have been pushing research, and encouraging applications for the metal. The AEC has been sponsoring research on powder metallurgy fabrication techniques at a number of companies and institutions, and the Air Materiel Command has just given Brush Beryllium Co. a $330,000 contract to develop a process for rolling thin sheet from sintered slabs. Both Brush and Beryllium Corp. have new plants–the latter (Oct. 7, p. 17) to produce the metal for the AEC at a contract price of $47 a lb (compared with current market price of about $71).

Chromium looks ductile . . .
but is extremely notch-sensitive and difficult to work. Even forging and swaging call for encasing the metal in an iron sheath. Bureau of Mines photos show pure metal, above; encased ingot, below, with a swaged rod beside it.

Beryllium is about 1½ times as rigid as stainless steel; and even at 600 F has a strength-weight ratio nearly twice as great. (At room temperature, its strength-weight ratio is greater than unity, and at 600 F, nearly 0.8. Stainless is less than 0.6 at room temperature; close to 0.4 at 600 F.)

Because beryllium's toxicity has been so widely publicized, it deserves a word of explanation. So far as is known, the metal–in massive form or in alloys– is not dangerous. But inhalation of some of its compounds is hazardous, so the metal requires special precautions in fabrication. AEC plants are, however, proving that it can be handled safely if treated with respect.

These and other special problems in fabrication make the cost of beryllium parts somewhat staggering. The Air Research & Development Command estimates the cost of finished beryllium shapes at $125 a lb compared with $15 for titanium. But the weight savings could justify even this differential.

CHROMIUM

Well known for its corrosion resistance, chromium has many alloying and plating applications. However, impact strength is low, even in high-purity form, and it has not yet found structural applications.

There are many reasons why engineers should be interested in pure chromium–relative abundance, heat resistance, nuclear properties, and strength. But, right now, there are almost no takers.

At room temperature chromium's impact strength–notched or unnotched–hovers close to the zero point. Above 220 F, it does undergo a transition, and its impact strength rises. But at about 1300 F, its impact strength may again drop off sharply–due to recrystallization and/or impurity pickup. So, despite intense interest in the metal, and a full-dress symposium on its properties a few years ago, unalloyed chromium seems to have little immediate value in structural applications.

VANADIUM

Relatively easy to work strong and light in weight, this metal deserves more attention than it has had.

Like chromium and columbium, vanadium is familiar as an alloying element, and was high on the stockpile list of critical materials. But since it is almost always found in connection with uranium, increasing amounts of it are becoming available. There is in fact more vanadium than uranium in most domestic ores.

Pure vanadium is considerably more ductile than chromium. But it is also more expensive ($79 to $80 a lb as compared with less than $6). It can be fabricated by most standard metalworking processes; has good thermal conductivity, desirable nuclear and electronic properties, and a high melting point. Above 110 F, though, it must be protected against oxidation.

Vanadium has been considered as a "getter" in electronic tubes, and also as a cathode material. Thermocouples have been made of it. There is considerable hope it may prove useful as a structural-material for nuclear reactors. Here its properties are similar to those of columbium, and it has been suggested as a cladding material for uranium, as well as for such mechanical parts as friction bearings.

HAFNIUM

An undesirable "impurity" for some applications, has many advantages in others. It offers excellent chemical resistance, good strength, and a high melting point.

Hafnium started its industrial life as a nuisance–a nuisance because it is found in association with zirconium, and the two are very difficult to separate. Since they're chemically similar, this did not seem to matter at first. Zirconium itself had few uses, and most of them involved corrosion resistance. Then came the atomic energy program, with its search for structural metals that would not absorb neutrons, and it was discovered that zirconium, freed of hafnium, is one of the lowest neutron-absorbers (0.4 barns); while hafnium is one of the highest (105 barns). The barely 2% of hafnium normally contained in zirconium can turn the latter from a nuclear asset into a liability. Now the two are being separated, and hafnium is becoming available in considerable quantity.

Hafnium has good corrosion resistance, and its melt-

ing point, hardness, and modulus of elasticity are all higher than those of zirconium. Right now, hafnium costs about $50 a lb, but a price half that high is in sight, and it might drop even lower.

COLUMBIUM

High strength, relative ease of fabrication, and increased supplies open structural and electrical uses.

Columbium is a familiar metal. Most people even recognize it by its international name, niobium. But until a few years ago it was so high on the stockpile list of strategic materials that the big design effort was to keep it out of products, not put it in. Government and industry scoured the world for columbium sources. Mine tailings that had even fractional percentages of columbite were purchased. Then improved refining procedures, and newly discovered reserves, changed the picture completely. Now new users are encouraged.

Columbium has much to offer. Like tantalum, with which it is often associated, columbium is strong, corrosion resistant, and heat resistant. It can be cold-worked, though it does have a tendency to seize or gall (as stainless steel does also). It can be resistance welded (though it needs protection from oxidation, since, like so many of the transition metals it picks up embrittling impurities at relatively low temperatures).

Columbium's biggest job to date has been as a stabilizer for stainless steel and high alloys. It shows considerable promise as a "getter" for electron tubes and as a material of construction for nuclear reactors.

Columbium would be a fine structural material for general use if it were less expensive. It's half the weight of tantalum, and has equal strength, plus excellent resistance to mineral acids (including concentrated nitric). But, at current prices, large-scale structural applications (outside the nuclear field) are not likely. (It's no more expensive than beryllium, and it is safer and easier to fabricate; but it doesn't have beryllium's weight advantage.) Nevertheless, there is intense interest in columbium, and much work is being done on fabrication techniques, protective coatings, and the like. Indeed, at least one major research program aimed at finding a self-regenerative, high-temperature coating has recently been switched from molybdenum to columbium.

RHENIUM

Electrical applications—alone or in combination with platinum—look like the best bet for this metal, but its high strength opens structural possibilities too.

If anyone wanted a ton of rhenium, its producers would be embarrassed. Four times as much rhenium will be produced this year as was made in the preceding 25—yet the total will be barely 1200 lbs.

Rhenium makes even platinum look like an abundant metal. Still, right now, there is enough of it around to make it worth considering for those applications, notably in the electronic field, where its unusually high melting point, high strength (tensile values at least to 350,000 have been obtained), relatively high resistance to oxidation (1000 F in some cases), may permit a small quantity of the metal to solve a big problem.

Rhenium is notable for the fact that it work-hardens faster than any other known metal, and its ductility decreases as the temperature rises. But strangely enough, rhenium seems to increase the room-temperature ductility of molybdenum. According to some reports, alloys containing 65% Mo and 35% Re can be cold-worked. Alloys of this type, incidentally, may prove valuable materials of construction for "fast" nuclear reactors.

Much research has been done on rhenium in the past few years, and several interesting alloys have been developed by such organizations as Battelle Memorial Institute for possible use in electrical contacts, thermocouples, and similar applications. (For additional information on rhenium, see Dec. 16 '57, p. 6)

REPRINT of this article can be obtained for your reference file by checking No. E13 on one of the Reader Service cards inside back cover. For other reprints available see "Current Reprints" listing in this issue on page 145.

FOR MORE DATA

Here is a selection of sources for information on each of these metals. Research institutions and government agencies also can supply much useful data.

Beryllium

Beryllium Corp. of America,
PO Box 1462, Reading, Penna.
Brush Beryllium Corp.,
4301 Perkins Avenue, Cleveland 3.

Bismuth

American Smelting & Refining Co.,
120 Broadway, New York 5
National Lead Co.,
111 Broadway, New York 6
Anaconda Co.,
25 Broadway, New York 4
Cerro de Pasco Corp.,
300 Park Ave., New York 22 (alloys)

Gallium

Aluminum Co. of America,
East St. Louis, Ill.
Anaconda Co.,

Columbium

Electro Metallurgical Co.,
Niagara Falls, N. Y.
Fansteel Metallurgical Corp.,
North Chicago, Ill.
E. I. duPont, Wilmington, Del.
Kennametal, Inc., Latrobe, Penna.
Kawecki Chemical Co.,
Boyertown, Penna.
Molybdenum Corp. of America,
Pittsburgh
Wa Chang Corp., Albany, Oregon

Indium

American Smelting & Refining Co.,
Anaconda Co.,
Indium Corp. of America, Utica, N. Y.
Consolidated Mining & Smelting Co.,
Montreal, Canada

Hafnium

Bureau of Mines, Albany, Oregon
Carborundum Metals Co., Akron, N. Y.
Columbia-National Corp., Pittsburgh 22
U. S. Industrial Chemicals Co.,
99 Park Ave., New York 16
Wah Chang Corp., Albany, Oregon

Chromium and Vanadium

Electro Metallurgical Co.
Vanadium Corp. of America,
420 Lexington Ave., New York 17

Rhenium

Dept. of Chemistry, University of
Tennessee, Knoxville, Tenn.
Chase Brass & Copper Co.,
Waterbury 20, Conn.

designing fluid circuits?

THROW IN THIS MAINTENANCE ADVICE

John Pippenger, *Double-A Products, Manchester, Mich.*

Richard M. Koff, *Associate Editor*

Here's a checklist covering the principles—preventive and trouble-shooting—that will keep hydraulic equipment working properly. Write such how-to tips in as part of the original design.

It's not always easy to write maintenance instructions to accompany a hydraulic circuit but the work pays dividends—significant design changes are often made as a result of the thinking required. Here is a summary of maintenance principles that cannot be ignored in a well-integrated design. They fall into two categories:

I—ELIMINATE NEED FOR REPAIRS

• Avoid nuisance fluid-leaks. Typical causes are: misapplied (or worn-out) seals; dirty, scratched, bowed or inadequately bolted joints; vibrating, unsupported lengths of flexible and rigid piping. Cure? Careful assembly, proper seals, periodic inspection. Only compatible materials (resistant to fluid and temperatures involved) should be used. External drains and protective devices can reduce seal wear.

• Eliminate vacuum leaks in suction lines to pumps and cylinder-prefill devices. Entrained air can cause spongy machine action and erratic feed. Suction leaks lead to noisy pump operation, cavitation, and early pump failure.

• Avoid shock. Install orifices or control valves to slow down each component so it is just fast enough to match required circuit performance. Limit the rate of pressure buildup. Adjust relief valves, counterbalance valves, and other circuit elements to avoid chatter, sudden pressure surges, and higher-than-needed (or lower-than-useful) working pressures. Pressure and flow are energy—use them efficiently.

Be aware of temperature. Specify oils that won't be too viscous when cold, too fluid when hot. Either may affect circuit timing and shock.

• Draw simple, logical JIC (Joint Industry Conference) chart. Specify placing it on or near the equipment. Also include a good parts-and-services list.

• Provide tips on recognizing troubles by noise, localized heat, erratic gage movement, vibration, sluggish operation, deteriorating insulation.

II—WHEN REPAIRS ARE NEEDED

WON'T WORK AT ALL

• Examine pump drive for loose coupling, wrong rotation, or low speed.

• Measure tank level. Is gage faulty?

• Disconnect pump outlet. If delivering, connect through proven relief valve back to reservoir. Is pressure high enough to operate the machine?

• Look for hidden broken pressure lines.

• Be sure no relief valves are stuck open.

• Trace circuit (using JIC chart). Is open-center directional control valve returning fluid to tank?

• See whether a piston rod is disconnected and causing fluid to leak (indicated by hot lines). Confirm by removing lines from cylinder and blowing compressed air through inlet ports. Also, blocking lines to cylinder may re-establish full operating pressures, indicating bypass through the cylinder.

NOISY PUMP

Hunt for suction leaks. Or if the pump is internally drained, check for vacuum leaks in the pump-shaft packing. Try flooding the pipe connections to the pump with the fluid being pumped. If noise stops momentarily, the point of air entry has been located.

• Examine alignment with drive motor. Misalignment may cause wear and noise.

• Make sure fluid is right for pump.

• See if relief valve is set too high. Are unloading valves properly controlling pump delivery?

(continued on page 72)

NOISY RELIEF VALVE

- Is valve piston scored and allowing too much control oil to pass through the integral pilot?
- Is control-chamber orifice too large for the viscosity of the fluid, resulting in a high-pitched whistle?
- Are relief valve and unloading valve pressures set too close to one another, causing flutter as the valves alternately control flow? Fluctuating back-pressures on internally-drained piloted relief valves will create a flutter on primary valve.
- Are pulsations from a worn pump too much for relief valve to smooth out?

VALVE FAILS TO OPERATE

- Is pilot pressure low? Supply orifice clogged? Main spool jammed? Drain restricted? Pilot tank port connected to a main tank port in which pressures are high enough to neutralize pilot input pressure?
- Does solenoid armature shift pilot spool far enough? Is voltage high enough? Are double solenoids improperly interlocked so that a signal is provided to both units simultaneously?
- Has mounting pad warped from hot fluid or external heating?

PRESSURE FAILURE AT END OF WORK STROKE

- Cylinder-prefill valve not closing properly—this will cause drain back to tank.
- Piston is disconnected from cylinder rod. Or piston packing is worn.
- Unloading or regenerative cross-over valve not functioning in regenerative circuit. Is valve leaking?

ERRATIC FEED

- Pressure compensator may be blocked or jammed open so that flow through orifice is not restricted, except as a function of load and pressure. Or it may be restricting flow. Binding can be caused by dirt inside, body warped from pipe strain, or tapered pipe threads jamming spool.
- Feed pressure might be lower than value of compensator springs. (Compensator stays wide open until pressure drop across orifice is high enough to actuate the spring-offset spool.)
- Alternate, uncompensated flow paths might result from excessive clearance flows through diversion valves, piston rings or other components.

FOAMING OIL?

- Return-to-tank line should be below fluid level.
- Tank baffling must be adequate.
- Fluid should be proper grade and clean.

DIRTY OIL?

- Internal dirt has accumulated—from scale, seal compounds, burrs, packing ends or temperature-deteriorated oil.
- External dirt got in—because of improper cleaning after servicing, inadequate screening at fill-pipe, faulty air breathers, or poor tank gaskets.

MOISTURE IN OIL?

- Cooling coils not below fluid level.
- Cold-water lines fastened directly against hot tank.
- Moisture in replacement oil. Tank drains will help.
- Extremes of ambient temperature.

SLUGGISH OPERATION, LOSS OF SPEED

- Check if wear is reducing pump flow.
- Look for hot pipes indicating internal leaks.
- Reaffirm setting of unloading valves. Is high-volume pump cutting out too soon?
- Are cylinder-prefill valves opening far enough?
- Are packings too tight on gravity-drop cylinders?
- Are machine slides set too tight for full-speed operation without triggering the pressure control that switches from high-volume low-pressure pump to low-volume high-pressure pump?
- Is spool on acceleration or deceleration valve stuck part way, restricting rapid traverse?

CYLINDER CREEP DURING IDLING

- An open-center valve with conventional single-rod cylinder will creep if there is restriction in tank port. Use tandem-type valve with pump and one cylinder port dumped while the other cylinder port is blocked.
- Closed-center valve can cause creep proportional to valve-clearance flow. Proper notching of valve spool can prevent pressure buildup in cylinder lines between cycles.
- Pilot-operated check valves can positively lock fluid in cylinder lines.

SOLENOID FAILURES

- Voltage too low? Too high? Wrong frequency? Double-solenoid valves energized in opposition? If voltage will not complete stroke of an ac solenoid it may burn out the coil.
- Were covers left off solenoids? Iron dust and chips can collect in the magnetic field; plunger may not complete stroke, burning out coil.
- Is armature shaft-end peened too short to actuate the valve?
- Are leads damaged? Look for shorts, open windings.
- Is spool tight? It may stick and burn out solenoid.
- Was wrong replacement spring chosen? If too stiff, it will overload solenoid.
- Are electric feed lines too light to carry needed inrush current?
- Are dirty contacts lowering inrush current?

FOOLPROOF—NOT IDIOT-PROOF

Keep in mind that some maintenance men pride themselves upon never reading instruction books. Yet success or failure of a product is in their hands. A partial solution is to make all critical adjustments tamper-proof (requiring special tools) and insist upon signed checkoff lists for all maintenance and repairs.

EDITOR'S NOTE: This article has been abstracted from a chapter in a book, "Fluid Control Valves," scheduled for publication in October by McGraw-Hill Book Co.

Mr. Pippenger is the author of a five-part article, "Hydraulic Control Valves," appearing Dec '56, p 174; Jan '57, p 196; Mar '57, p 144; May 57, p 167; and July '57, p 197.

textured steel

FORD R. PARK
Associate Editor

SPECIAL REPORT
Product Engineering

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WHEN TO USE IT

HOW IT'S MADE

WHERE IT'S APPLIED

TIPS ON DESIGN AND FABRICATION

TWO NEW COLOR PROCESSES

TRENDS IN DESIGN

Consumer demand for frequent product restyling is worth listening to, but need not always require trips back to the drawing board for expensive major redesign. A low-cost alternative receiving increased attention is the texturing of steel surfaces and fittings. It offers patterns with eye appeal, product identification, and these other advantages, functional as well as decorative:

- The color finishes available add richness and depth to the pattern. Synthetic enamels, colored lacquers, porcelain enamels, plated metals, oxidized coatings, and plastic laminates give corrosion resistance as

well. Unusual effects like wood grain, leather, and cloth are created by coloring the appropriate texture with two-tone paints, lithographed over-patterns, or highlighting.

- Reflection of light from broad flat surfaces, can be controlled because texturing changes a single mirror surface to many surfaces.
- As camouflage for marks, dents, and scratches, texture prolongs a product's "new" look. Similarly, it reduces the number of rejects in automatic manufacture where, with parts handled faster, it is harder to maintain smooth surfaces. Fasteners like screws and spot welds are easily hidden in the pattern; so are perforations for sound transmission or ventilation.
- Dimensional proportions of a product can be "altered" by directional texturing. A tall housing for an outboard motor, for example, might be made from horizontally textured stainless to give a lower, sleek appearance.
- Mechanical strength and rigidity can be increased, particularly in deep-texturing processes. With lighter gage sheet, this saves considerable weight in many parts without loss of rigidity. Where expensive stainless steel is a must, such weight reduction can keep costs in line.
- Cheaper grades of steel are possible where post-plating provides the finish. For example, No. 2 mill finish for plain plated surface requires expensive grinding and buffing before plating; these costs are eliminated when a textured surface is plated.
- Structural materials are upgraded with a thin facing of textured steel applied for functional or decorative reasons. Example: Sandwich panel construction where the core is plywood, hardboard, or foamed plastic.
- Skid or nonskid characteristics can be built into textured steel by adjusting the ratio of raised to depressed area and the angle of high points. Surfaces in carton-handling and food-processing machines are often deep-patterned this way to prevent suction and subsequent jamming.
- Increased surface area of deep-textured steel gives increased heat transfer from the surface. Percentage increase is not high, but useful where design meets a borderline problem.

HOW IT'S MADE

Textured steel is produced by rolling plain sheet or strip stock between forged-steel rolls — one or both of which carry the pattern. Texturing between two meshing rolls gives a different material from rolling between a patterned and a flat roll. Both may look alike but the two do not have equal rigidity and strength, or take the same coloring methods.

Coined or embossed patterns are rolled between a smooth bed roll and an upper roll containing the etched design. Over-all thickness of the material remains the same. Steel is thus work-hardened considerably and, where the pattern is sharply defined, locally sheared. Deeper textures therefore require thicker stock. Section modulus drops because of local thinning, but texturing compensates for this by adding

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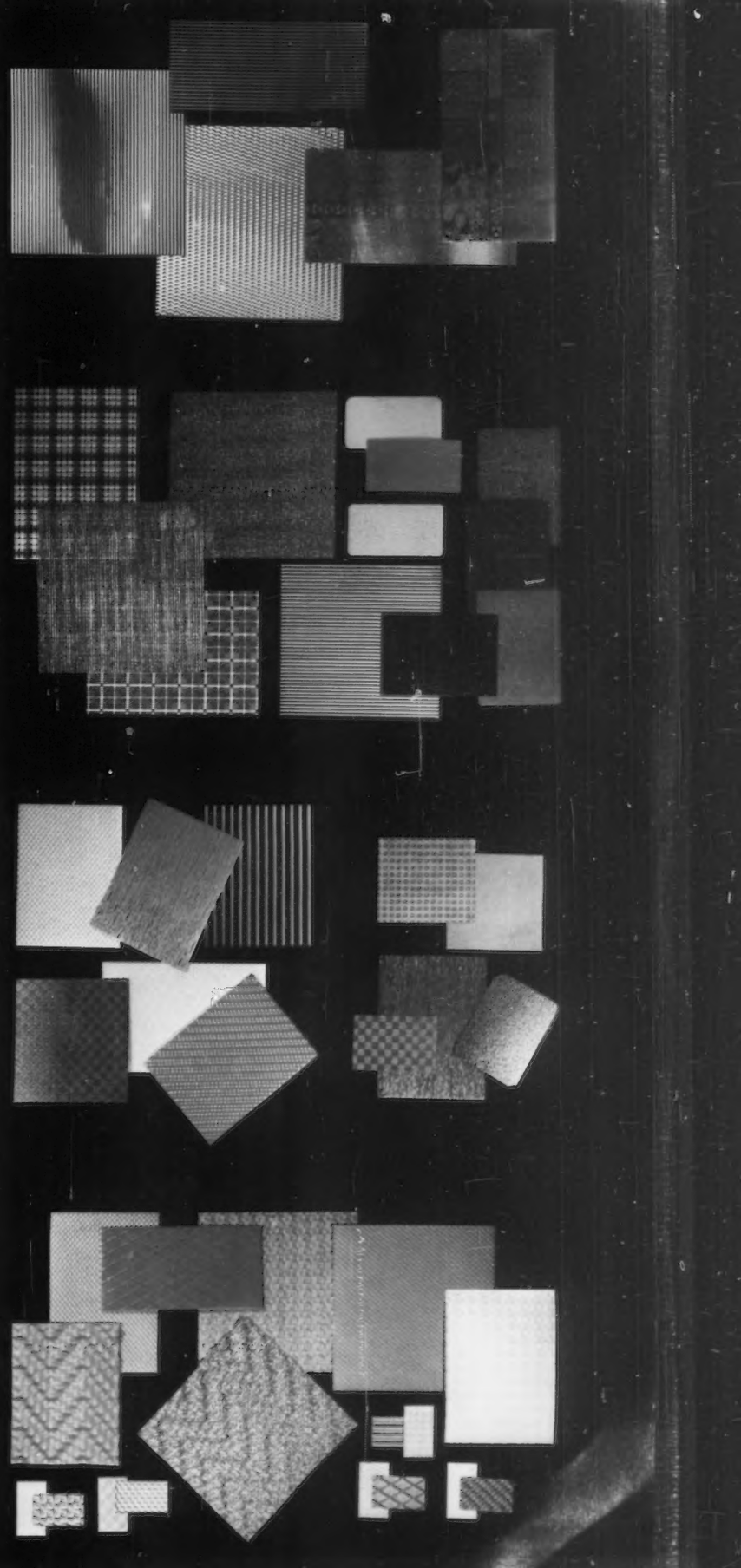
TEXTURE PLUS COLOR

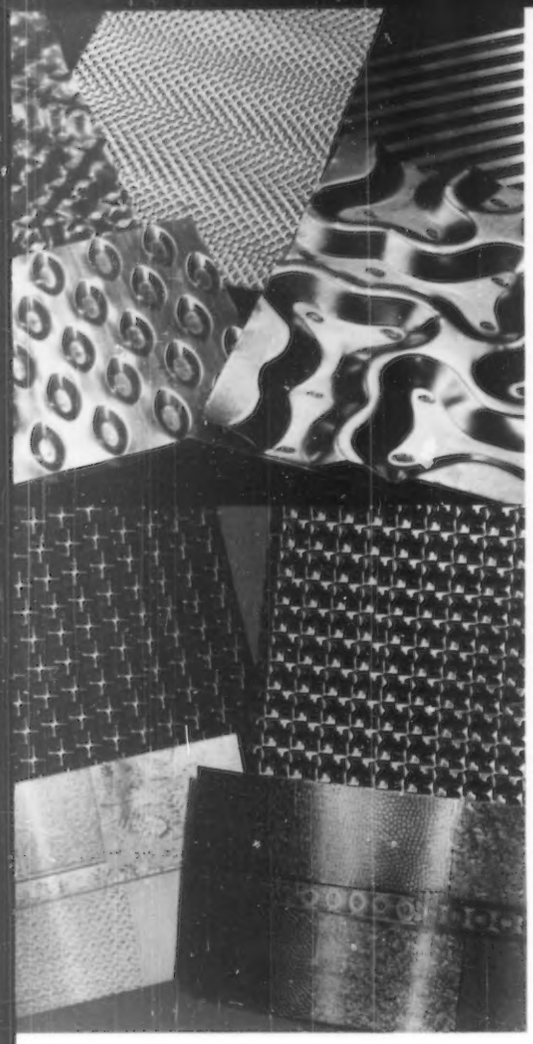


Preplating adds color . . . of traditional metals to crimped or coined textures — the warmtth of copper, richness of brass, blue sheen of chrome.

Metal becomes make-believe . . . cloth, wood, or leather. It's easily done by lithographing, silk-screening or painting before or after texturing.

Highlighting stainless . . . gives sparkle and color. Samples at left are painted or porcelain enameled, those at right show oxidized finishes.

Texture on texture . . . with plastic laminates adds to subtle touch and color as well. Large panels are vinyl-clad, small panels are covered with metalized Mylar before rolling.



Texture gives rigidity to perforated sheet (top), and spot-welding to facing panels makes structure with high strength-weight ratio.

Coining and Deep-texturing give different products. Brass-plated sheet has coined pattern on only one side. With deep-texturing, stainless panel has pattern on both sides, enameled and highlighted.

strength; if thinning is serious, specify heavier gage material.

The method requires high pressures. Ductility is reduced, but proper gage and hold-down pressure allow max draws of about 4 in. Coining is applied primarily to coiled strip stock, with a max width of 26 in. to date, thicknesses ranging from 0.009 to 0.110 in., and pattern depths from 0.001 to 0.010 in. Narrow widths are obtained by slitting wider embossed strip, requiring less handling and causing less wear on the rolls.

With coining, random texture designs are possible. A pattern simulating leather or a floral design, for example, could not be made with meshing rolls. Color is achieved by preplating with brass or copper, or by spray-painting after the part is formed. A new process involving colored aluminum coatings is described on the next page. Some prepainted steel is coined, and antique oxidized finishes are under development.

Deep-texturing is a drawing operation. Sheet or strip is patterned between meshing rolls, and the metal is redistributed above and below the neutral axis – often well outside the original thickness. This increases the area moment of inertia and hence the rigidity, so a lighter gage material is often possible. Less work-hardening results than with coined textures, but meshing of two rolls imposes two limitations: Random patterns cannot be produced, and the reverse side is not smooth – occasionally a fabrication problem with the deeper patterns. The illusion of a random pattern is possible by clever roll design, however. For example, textures simulating splintered wood and hammered copper have been produced.

Primarily applied to sheet steel, deep-texturing rolls currently go up to 52 in. width and a max pattern depth of 0.320 in. Top gage in carbon steel is 0.081 in.; in stainless, 0.075 in. About 75% of the steel deep-textured today is 48-in.-wide sheet from 0.015 to 0.025 in. thick. Color can be added prior to rolling; prepainting, plating, plastic cladding, and lithographing – and combinations of these – are suitable. These color coats are formable too. Non-formable coloring, added after texturing, includes some synthetic enamels, porcelain enamels, and oxidized coatings.

Crimping, a third texturing method, is done in meshing rolls, and is primarily applied to preplated steels to increase the number of reflective surfaces. The metal is cold-worked very lightly and can be crimped in more than one direction for special effects. A crimped sheet is more rigid than a plain one, but because of the gathering effect, more material is needed for the same area.

DESIGN PROBLEMS

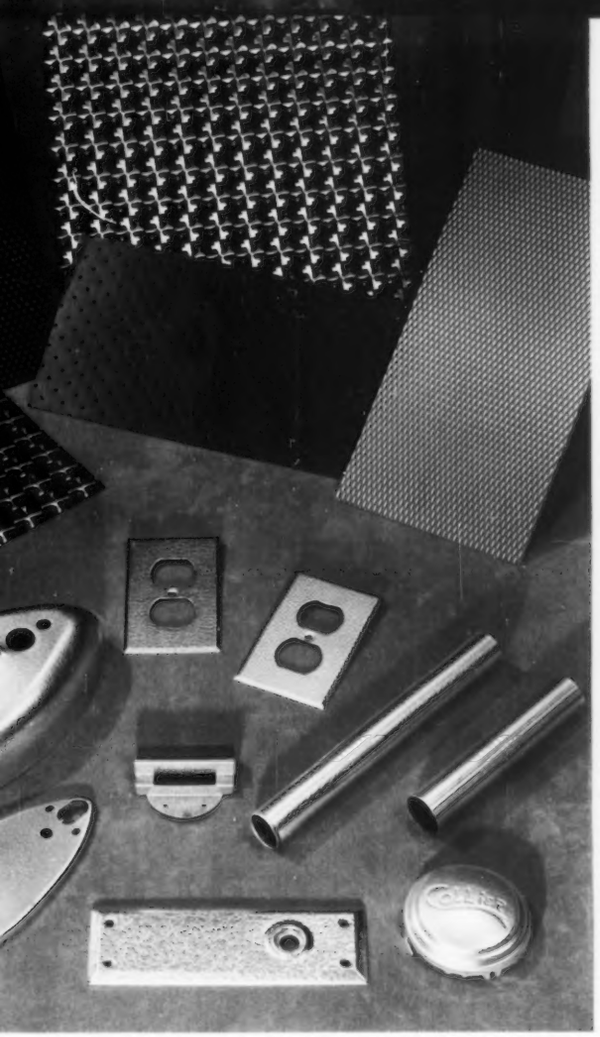
Design of parts follows established sheet metal practice, and the same tools will usually work. However, the new elements in the design – texture, and possibly color – must be kept continually in mind as the drawings are prepared and first fabrication begins. Here are some problems to watch for, and solutions for them:

- **Flat bending** gives the most trouble because the bend tends to follow the pattern. With random textures this is not a problem, but with directional patterns bending along the edge of the design will often cause cracking – particularly when the pattern is sharply defined. This occurs more often in coined sheet.
- **Forming-die** clearance must be sufficient for the combined thickness of sheet and texture. With existing dies, different gages and texture depths should be tried until a part with minimum weight but adequate stiffness is achieved. Bend radii should be no tighter than twice the combined thickness for deep-textured steel, and 1T for coined stock. Smaller radii will give excessive pattern distortion.
- **Drawing** depth is limited to about 4 in. for coined sheet, and 1 in. for deep-textured. These figures are not absolute for all patterns and gages in each category. Trial draws are the best guide, and the only way to evaluate pattern distortion – the most serious obstacle in deep-drawing.
- **Spun shapes** in shallow draws are possible with all but the deepest patterns. Spinning against a wood form keeps the pattern from flattening.
- **Die wear** will be higher than for plain steel, and higher for deep-textured material than for coined. Die life can be extended with preplated or prepainted steel. Undercoatings for paint, like aluminum and zinc, also improve die life.

1

Stainless panels have been colored with a new coating developed by Electro Metallurgical Co., Div. of Union Carbide. Surface preparation, coating formulation and process control form a tenacious bond – yet the coating has sufficient ductility and abrasion-resistance for post-forming. Almost all colors are possible and a specific range of colored coatings is being prepared. The process will be applicable to other metals, is continuous rather than batch, and first application will be to patterned exterior panels for the new 52-story Union Carbide building in New York.

TWO NEW



2

Color has been added to these parts by dyed epoxy enamel electrostatically sprayed on an aluminum coating applied to the textured surface by vacuum metallizing. Developed by the Perfection Finishing Corp., Wauseon, Ohio, the process applies reproducible colors to finish-formed parts of textured steel — material here is patterned strip from Sharon Steel Co. The soft aluminum coating is protected by oven-curing the epoxy enamel. This protection combines with the natural corrosion resistance of aluminum and that of an oven-cured prime coat of enamel, to give corrosion resistance superior to chrome plate — salt spray life in excess of 100 hours. Continuous operating temperatures of 225-250 F are feasible based on 300-F oven-cure for the enamel. Parts are enameled continuously on a conveyor, but aluminized on racks.

V PROCESSES

● **Paint coverage** is different than for plain sheet because of the sharp pattern edges on which the paint thins as it dries. This will emphasize pattern, but the usual 1-mil paint thickness gives incomplete hiding. Two-tone paint finishes combine with texture to simulate leather, wood and cloth.

● **Pattern direction** must be watched carefully at all stages — design, bills of material, layout in the shop, and fabrication — or excessive waste results. Incorrect nesting of parts on a blank, for example, can cause mismatch of adjoining parts at assembly.

● **Residual** compression stresses in the textured side of coined sheet may cause bowing in large flat areas. Turning flanges away from this surface will induce sufficient corrective tension.

● **Edges** of thick coined sheet or strip look bare because the pattern is only on one surface. Hiding methods include: lock-seaming, turning the edge away from the eye, butt-welding, covering with molding, and — with thinner deep textured sheet — lapping and spot-welding.

● **Sheared edges** on blanks for drawing must be deburred more carefully than for plain steel because the pattern introduces stress raisers in the surface. Consequently, forming which puts the edge in tension may tear the sheet.

● **Butt-welding** with deep-textured materials requires flattened edges when pattern depth exceeds 0.015 in. Edge-flattening also helps in welding. Spot welds that do not distort the texture are made by nesting flat copper wire braid between electrode and pattern.

● **Roll cost** becomes important when an exclusive pattern is desired. Deep-texturing rolls, because there are two of them, are more expensive than coining rolls. This is somewhat offset by higher wear rates on coining rolls. An exclusive pattern requires from 20-25 tons of textured steel per year to make roll cost economical, but if the design can be released to other fabricators for even limited use, this tonnage can be lowered.

pages 76-78

TRENDS

Three main areas of research and development on textured steel are likely to expand its utility in product design:

● Coloring methods to compete strongly with anodized aluminum. Besides the established coloring techniques shown here, and the two new methods shown on previous page, development is underway on: formable colored lacquers applied to textured tin-plate, ductile coatings applied by vacuum deposition, multicolor spray enamels, and new oxidizing finishes.

● Deep-textured patterns as an alternative core for honeycomb sandwich panels in aircraft and missiles. With metal facings adhesive-bonded to both sides of these cores, structural composites can be formed having two passages for heat-transfer media.

● Wider textured sheets for bigger parts. Present demand is for patterns 60 in. wide, a requirement that may be met by 1959.

EDITORS NOTE: This is the sixth in a series of recent full-color reference articles on colorful finishing methods for metals. Other techniques adding identity and eye appeal to products are covered in the following:

"Prepainted Steel," Dec 9 '57, p 99. How to specify this colorful, functional, economical material.

"Color and Textures for Aluminum," Sept 30 '57, p 101, discusses several surface treatments — mechanical, chemical and electrochemical — plus some coloring methods peculiar to aluminum.

"Color Finishes for Copper," Dec '56, p 135, lists finishes obtainable by chemical conversion and mechanical treatment.

"Vinyl Laminate," July '56, p 167 — opportunities presented by new adhesive bonding method.

"Prefinished Aluminum," April '56, p 135, shows how electrochemical, paint, and electroplated finishes withstand forming; describes mill products available in prefinished chemical colors.

ACKNOWLEDGEMENT: Information helpful in the preparation of this article came from: American Nickeloid Co., Peru, Ill.; Apollo Metal Works Inc., Chicago; Ardmore Products Inc., Kenilworth, N. J.; Croname Inc., Chicago; Electro Metallurgical Co., New York City; Fabrite Metals Corp., Brooklyn; Perfection Finishing Corp., Wauseon, Ohio; Rigidized Metals Corp., Buffalo; Seiberling Rubber Co., Barberton, Ohio; Semrow Products Co., Chicago; Sharon Steel Corp., Sharon, Penna.; Sun Steel Co., Chicago; Thomas Strip Div., Pittsburgh Steel, Warren, O.

Steel hub is bonded . . .
to cement grinding wheel. Adhesive protects inner surface from corrosion by cocoa bean oil and aligns wheel on shaft.

WHICH ADHESIVE FOR WHAT

Today's adhesives are many and can develop terrific strengths—but only if applied the right way, to the right material. This guide includes a table you will want to file for fast reference.

R. W. JAMES AND R. W. GORMLY

Arthur D. Little, Inc.
Cambridge, Mass.

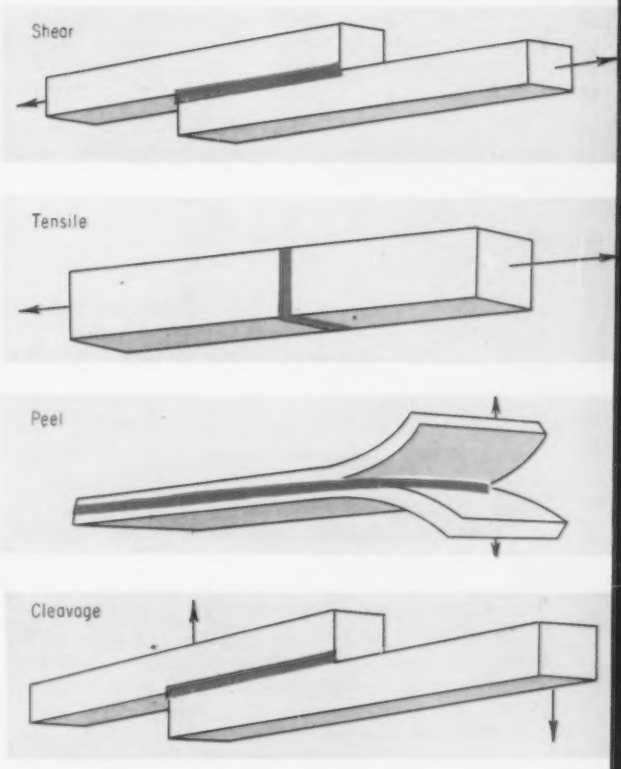
Ideally, there should be one super-glue to bond anything and everything. But because no one adhesive can do it all, the answer has to be a practical one—especially with the type called structural adhesives. Fortunately, as the table on next page shows, there are now so many available that the right one can be chosen for almost any specific bonding problem.

What They Must Do

A structural adhesive is called on to do more than just glue things together. It must permit the bonded parts (adherends) to support loads greater than their own weight—and without creep or rupture. This type includes adhesives for bonding plywood, laminated beams, brake linings, sandwich panels, metal-to-metal assemblies. It excludes adhesives that simply hold materials like paper and floor coverings in place, or those used primarily for sealing or calking.

How They Vary

Each structural adhesive will bond some materials well and others poorly. Some are elastic, others rigid. They differ in mechanical strength and resistance to cleavage or peel. They have different resistance to moisture and elevated temperatures. The solvents in some



Where structural adhesives excel . . .
They are best under shear and tension (top). By contrast, nonstructurals are better in peel and cleavage (below).

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Chemical Type	BONDING ABILITY: Aluminum	Other metals	Glass	Plastics, low m.p.	Plastics, heat resistant	Wood	Rubber	Leather	Ceramics	Concrete	BONDING REQUIREMENTS: Temp., F	Pressure, psi	Time
Urea-formaldehyde	P	P	P	P	M	E	P	G	P	P	70 to 260	50 to 200	5 min to 4 hr
Melmaine-urea formaldehyde	P	P	P	P	G	E	E	E	M	P	240 to 280	100 to 250	5 to 20 min
Phenol-formaldehyde	F	P	P	P	M	M	E	M	G	P	70 to 300	25 to 250	1 min to 4 hr
Resorcinol-formaldehyde	F	P	P	G	G	E	E	E	G	P	70 to 200	25 to 250	3 min to 2 hr
Phenolic-elastomer	E	G	G	P	G	E	G	E	G	G	350	50 to 300	30 to 60 min
Epoxy	E	E	E	E	E	E	E	E	E	E	70 to 400	Contact to 200	15 min to 4 hr
Epoxy-phenolic	E	E	E	P	G	E	F	E	E	E	350	25 to 200	About 2 hr
Epoxy-polyamide	E	E	E	G	G	E	G	E	E	E	70 to 300	Contact to 100	10 min to 5 hr
Epoxy-thiokol	E	E	E	G	E	E	E	E	E	E	250	Contact	30 min to 2 hr
Neporene base (thermoplastic)	F	F	F	G	F	F	E	E	G	G	Solvent release, to 210	Contact to high pressure; while tacky	Momentary
Other curing elastomer systems (thermoplastic)	P	F	F	F	F	F	G	G	P	P	Solvent release, 70 to 325	25 to 500	5 min to overnight

Code: E—excellent; G—good; M—moderate; F—fair; P—poor.

Note 1. Soluble in aromatics, esters, chlorinated hydrocarbons.
Note 2. Soluble in ketones and esters.
Note 3. About 50 psi for sustained dead load.

may ruin certain base materials. And, of course, they vary widely both in cost and in method of application.

Type of Bond

There are two ways the bond is accomplished:

In mechanical bonding, the adhesive infiltrates porous materials to give cementing of a physical nature—as in glueing wood.

In chemical bonding, the adhesive reacts with the parts, or joins them largely through intermolecular attraction.

The bonding forces act singly or in combination to grip adherends together under shear, tension, peel or cleavage. To resist creep, the adhesives must be quite rigid and also have good shear and tensile strengths. But thermosetting adhesives with these properties have poor resistance to peel and cleavage. For high loads, design the joints so stresses are in shear, and distribute them evenly over large areas.

Nonstructural adhesives, by contrast, being usually thermoplastic, soften and lose strength rapidly with moderately elevated temperature. Since they are somewhat elastic, they resist peel and cleavage well, but have poor shear and tensile strength, and also creep and deform under continuous loading.

Method of Bonding

Adhesives come in different forms—liquid, paste, films, or powders. The form usually determines method of application: Liquids can be sprayed, roller-coated or brushed; paste, troweled; and powder, dusted. How the adhesive is applied can make a big difference in the labor required. In any case, the film thickness must be accurately controlled—if too thin, the adhesive may give incomplete coverage; if excessively thick, bond strength is decreased.

Thermosetting structural adhesives must react chemically under pressure and heat to become rigid, infusible, and insoluble. Pressures required range from contact pressure to several hundred psi. Contact is quickest but does not allow adjusting of misaligned joints. High pressures require clamps or presses. Temperatures needed range from room temperature to 400 F. At room temperature adhesives cure slowly and may only develop full bond strength after 2 to 3 days. High bonding temperatures require expensive heated fixtures.

Trouble-shooting Tips

An over-all compatibility between adhesive and adherend is required. Here are some warning signals:

STRUCTURAL ADHESIVES

RESISTANCE OF BOND TO:				ROOM-TEMPERATURE BOND STRENGTH	
Water	Organic solvents	Heat	Cold	Shear, psi	Peel, lb/in.
F	G	G	G	Chief use in plywood. Shears in the wood. Maple, 2800 psi Birch, 450 psi	Not applicable
E	E				
G	G				
E	G				
				On Aluminum	
E	E	E	E	3000 to 5000	40 to 60
E	E	F to E	E	1000 to 5000	20 to 100
E	E	F to E	E	2000 to 3000	40 to 100
E	G	F to G	E	2500 to 3500	15 to 30
E	E	F	E	4000	20 to 35
E	P Note 1	P to F	G	400 on Al Note 3	10 to 20 on leather
G	P Note 2	P	G	Up to 1200 on Al	13 for steel on fir plywood

• For transparent adherends, avoid an adhesive whose strength would be lowered by the effect of light.

• For plastics, choose adhesives that will not craze or dissolve adherends. If plastic contains plasticizer, it may migrate into the adhesive and soften it.

• For porous materials, an adhesive that soaks through may cause staining.

• On aluminum, alkaline adhesives cause corrosion.

• On a copper-base alloy, natural rubber adhesives will deteriorate.

REPRINT of this article can be obtained for your reference file by checking No. E14 on one of the Reader Service cards inside back cover. For other reprints available, see "Current Reprints" listing in this issue on page 145.

EDITOR'S NOTE: For articles with additional information on fastening with adhesives, see

"Single Component Epoxy Adhesive," May 57, p 165. Paste adhesive developed for non-aircraft use has moderate tensile shear strength to 250 F; retains form during curing.

"Joint Design for Adhesive Bonding," Mid-Oct 56, p G10. Discusses design for good adhesive joints.

"Adhesive-bonded Metal Joints," July '55, p 170. Room-temperature tensile shear strengths of eight adhesives, including rigid types of plastic rubber-resin compounds.

SHOPPING LIST FOR STRUCTURAL ADHESIVES

(Not necessarily complete, but a good starting point)

Urea-formaldehyde

American Cyanamid Co.
Bakelite Co.
Borden Co.
Barrett Div. Allied Chem.
Catalin Corp.
National Casein Co.
Monsanto Chemical Co.
Paisley Products Inc.
Reichhold Chemicals, Inc.
US Plywood Corp.

Melamime-urea-formaldehiyde

American Cyanamid Co.
Rohm & Haas Co.
Monsanto Chemical Co.

Phenol-formaldehyde

American-Marietta Co.
Bakelite Co.
H. B. Fuller Co.
B. F. Goodrich Co.
Heresite & Chemical Co.
Imperial Chemical Ind., Ltd
Monsanto Chemical Co.
Minnesota Mining & Mfg. Co.
Varcum Chemical Corp.
Xylos Rubber Co., Div.

Resorcinol-formaldehyde

B. F. Goodrich Co.
Koppers Co.
Monsanto Chemical Co.
Synco Resins, Inc.
Synvar Corp.
Naugatuck Chemical Div.
Durez Plastics Div.
Schenectady Varnish Co.
Polymer Chemical Co.

Phenol-elastomer

B. F. Goodrich Co.
B. B. Chemical Co.
Bloomingdale Rubber Co.
Compco Chemical Co.
Cycleweld Cement Products
Pierce & Stevens, Inc.
Rubber & Asbestos Corp.
Borden Co.
Hughes Glue Co.
Narmco Resins & Coatings Co.
Xylos Rubber Co.
Armstrong Cork Co.

Epoxy

Alkydol Laboratories Inc.
Ciba Co.
Bakelite Co.
Rubber & Asbestos Corp.
Nureco Inc.
Armstrong Products Co.
Furane Platics, Inc.
Loven Chemical of California
Marblette Corp.
American Latex Products
Paisley Products, Inc.
US Stoneware Co.

Epoxy-phenolic

Adhesive Engineering
Lebec Chemical Corp.
Plastics Engineering Co.
Slomons Laboratories, Inc.
Narmco Resins & Coatings Co.

Epoxy-polymide

Adhesive Products Corp.
Borden Co.
Rubber & Asbestos Corp.
Chemical Coatings & Engineering Co.
Ohio Adhesive Corp.
Narmco Resins & Coatings
Houghton Laboratories, Inc.
National Starch Products
Lawrence Adhesive & Chemical Co.
General Mills, Inc.

Epoxy-Thiokol

Rubber & Asbestos Corp.
Polymer Chemical Co.
Borden Co.
Armstrong Cork Co.
Minnesota Mining & Mfg. Co.
Polymer Industries, Inc.
Atlas Mineral Products Co.
Loven Chemical of California

Neoprene base (thermoplastic)

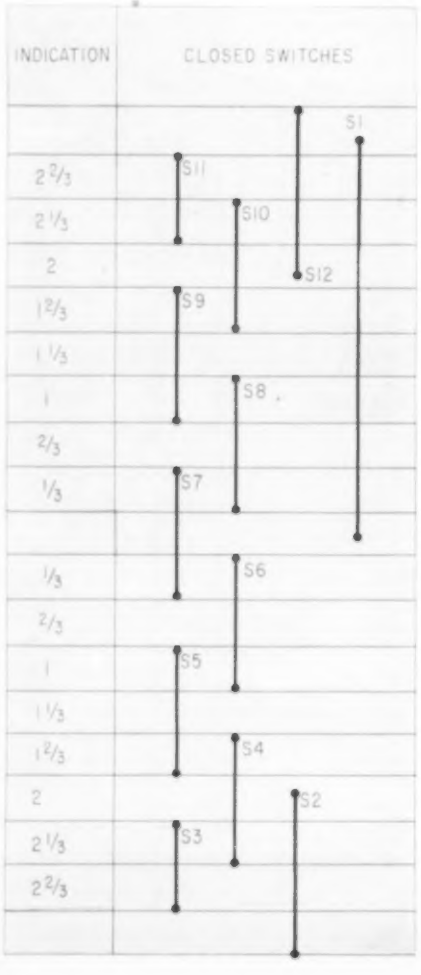
Goodyear Tire & Rubber Co.
Marbon Chemical Div.
Formica Corp.
Pierce & Stevens, Inc.
US Rubber Co.
Cycleweld Cement Products
Minnesota Mining & Mfg. Co.
Union Paste Co.
Carboline Co.
Dewey & Almy Chemical Co.

Other curing elastomers (thermoplastic)

US Rubber Co.
Angier Adhesives Div. Interchemical Corp.
Pierce & Stevens, Inc.
Armstrong Cork Co.
US Stoneware Co.
Rubber & Asbestos Corp.
Du Pont

Conveyor weighs packages . . . of bacon as it moves them from slicing machine to pair of attendants. Each woman watches a lighted panel facing her—one of two that take turns flashing instructions. She sees "Pass" if weight is OK; if incorrect, she sees "Add" or "Remove," and how much adjustment to make. Her corrections are in ¼-slice increments up to 2¾ slices. Then packages go on through flap-folding stations to a machine for final wrap-up.

For weighing, conveyor serves as a beam scale. It varies pressure in an air line by changing the clearance at an exhaust jet. The amplified pressure signals operate a pressure switch that selects message flashed to attendant. Switch is a shaft carrying 12 cams that close contacts to form a unique computing circuit.

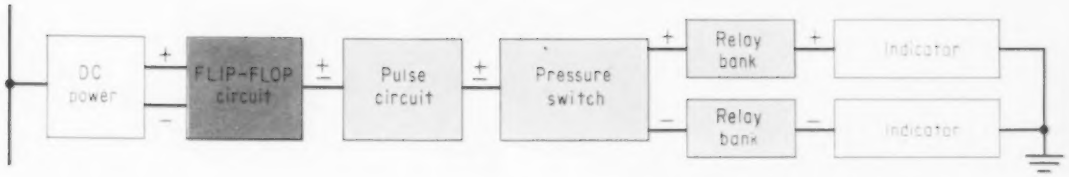


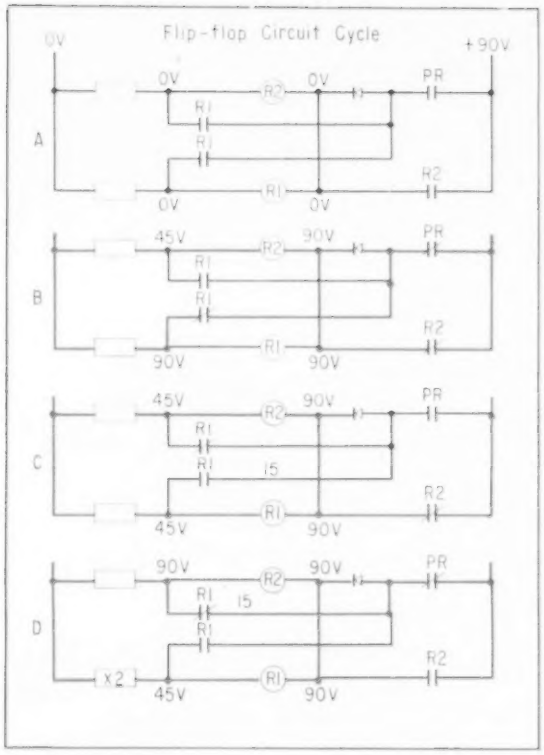
Scale Computes Weight Correction

Along the bacon-packing route, this conveyor becomes a scale that weighs packages and, using cam switches and relays, tells operators how much meat to add or remove.

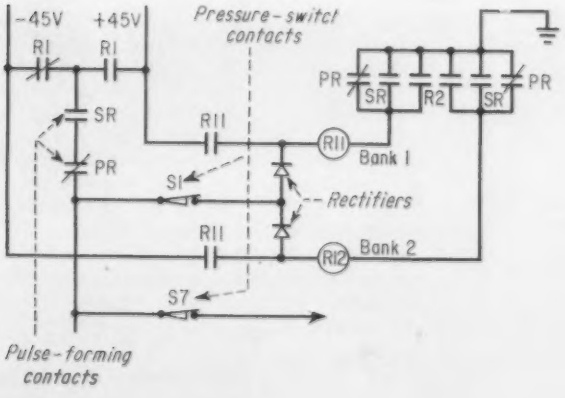
Machine cuts bacon slabs into shingled groups of slices, places the slices on paperboard, indicates deviation from a preselected weight, then transports the weight-corrected packages to overwrapping machines. Result: packages that are never underweight, with minimum bacon giveaway. Packaging line was developed by Emhart Mfg. Co. and is sold by their Standard Knapp Division, Portland, Conn.

IN NEW PRODUCTS

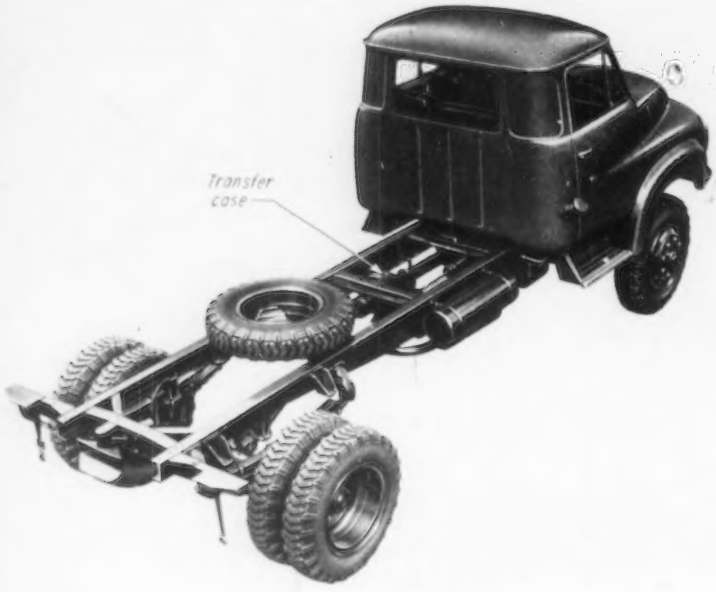




The computing circuit . . . translates switch positions into an instruction and a weight indication, and flashes data for successive packages alternately on opposite panels. Relay circuitry is simplified by using current pulses of opposite polarity to send data to each panel. Pulses are generated by relay contacts (not shown) actuated when a package moves on the scale. Pulse polarity is established by a flip-flop circuit that operates as each package enters and leaves the scale. Contact PR closes each time a package moves on the scale and alternately energizes and de-energizes relay R1. This relay has normally open and normally closed contacts in the pulse-generating circuit that controls polarity.



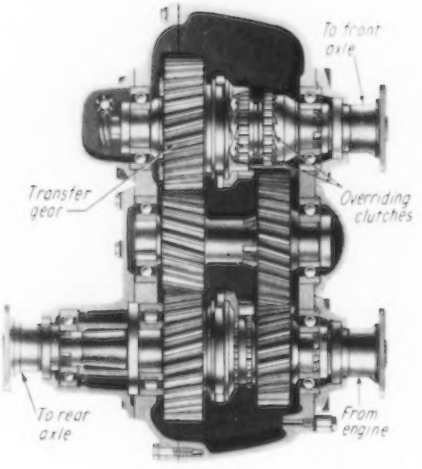
Switch contacts . . . direct pulses to relay banks that energize indicator lamp circuits; rectifiers let pulse polarity determine which relay is energized. Each relay has a holding contact and stays energized until contacts PR, SR and R2 open. Contact SR closes when a package moves on the scale and energizes relay PR which opens its contacts after a short delay. This action generates pulse that operates relay banks.

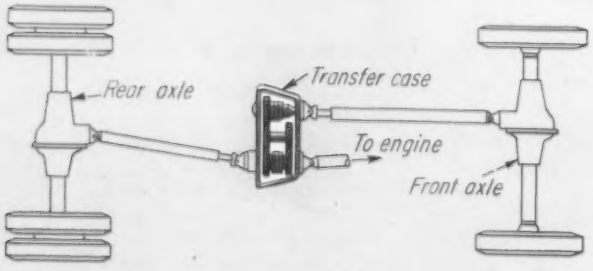


Goes into 4-Wheel Drive Automatically

Front drive has an overriding clutch. It engages only when rear wheels start turning faster than front ones—indicating need for extra traction.

Freewheeling front-wheel drive was designed into German Ford truck to reduce wear of front tires and drive mechanism and to improve fuel economy. The 5-ton-rated G-700 is powered by a 125-hp, 2-stroke diesel of 256-cu in. displacement that delivers more than 217 ft-lb of torque from 1100 to 2800 rpm.



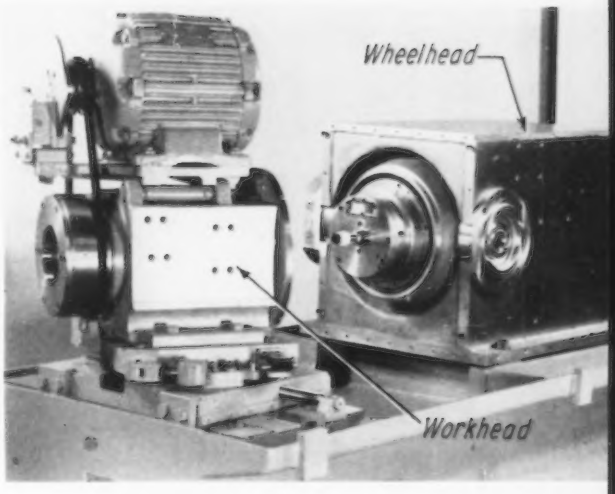


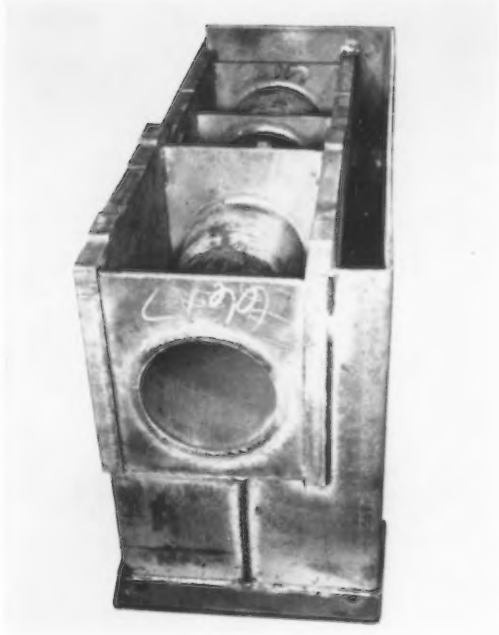
Transfer case is brain . . . of freewheeling drive and includes an additional reduction gear of 1:1.9 ratio to give operator a choice of 8 forward and 2 reverse gears. Overriding clutch is between transfer gear and shaft that drives front axle. Transfer gear, with one more tooth than gear in drive to rear wheels, turns at fewer rpm than either drive shaft. This lets the clutch override and causes front axle to freewheel. If the rear wheels start to slip, the transfer gear speeds up, the clutch engages and torque is delivered to the front wheels. A second clutch acts the same way when drive is in reverse gear.

Grinder Supports Reduce Vibration

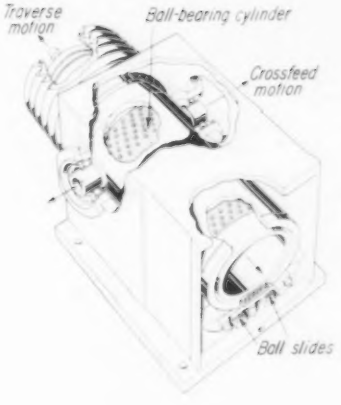
Crossfeed and traverse drives for internal grinder are in same plane as axis of grinding wheel. They reduce bending moments and vibration by passing cutting forces along to rigid structures that lead them down to the base.

Slides that support spindle ride on preloaded ball bearing surfaces for stable alignment in this grinder designed by Bryant Chucking Grinder Co., Springfield, Vt. Wheelslide and workhead are self-contained assemblies suited for mounting in any position on a base or for use as modular components in transfer lines.

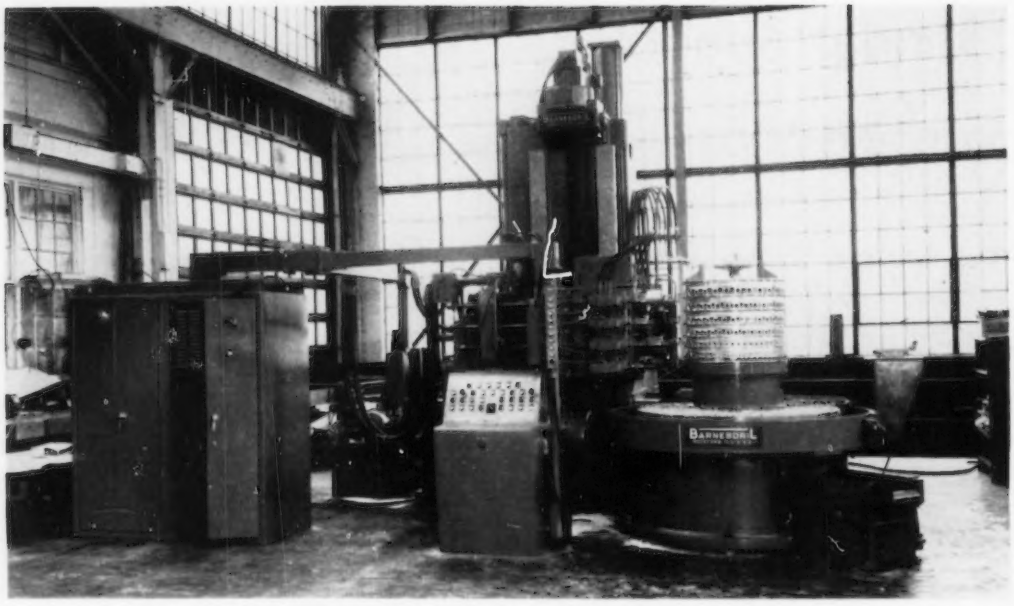




Base is rigid and light . . .
to reduce deflection and obtain a high natural frequency. Top section is formed by welding side plates to webs that are reinforced by a central tube. Bottom section is simple wrap-around steel shell. With high-frequency motor driving the grinding wheel, vibrations transmitted to the structure are reduced.

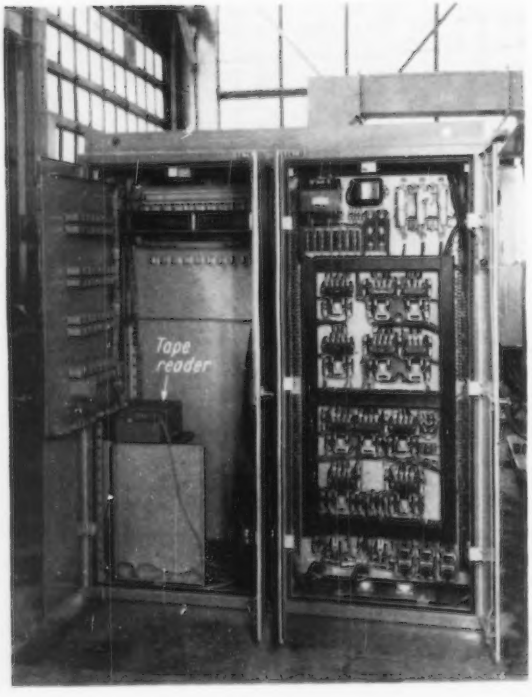


Spindle in tubular slide . . .
is supported by a ball-bearing cylinder inside a cylindrical shell. Housing is supported at three points—two trunnions at front, a horizontal ball slide at rear. Trunnions transmit forces to housing while rear ball slides absorb vertical moments. Rigidity results from preloading all ball bearings and from box-and-tube configuration which avoids transmission of forces through cantilever structures. Crossfeed drive mounts on wheelhead at trunnion centerline and has nut-and-screw drive to keep forces axial. Wheelslide is traversed by an axially mounted, servo-controlled hydraulic cylinder.



Tape Controls Multifunction Drill

Punched tape controls four-spindle drilling and boring machine designed to work on cylindrical parts up to 50 in. in dia and 40 in. high. As many as four operations can be performed on each hole.



Machine illustrated is set up to put 248 holes into a compressor casing. Holes are of three sizes and each requires three operations—finish boring, and generation of front and back counterbores while holding wall thickness within tolerance. Position accuracy is held to 0.005 in. and repeatability within 0.001 in. Machine was built by Barnes Drill Co., Rockford, Ill., and uses control equipment made at General Electric's Specialty Control Department, Waynesboro, Va.

Position information . . .
is punched in standard 8-channel tape. Vertical data is recorded in 0.001-in. increments; rotary indexing data in degrees and fractions of degrees. Smallest indexing increment is 0.002°; this is 0.001-in. linear displacement at a radius of 27½ in. Table is always indexed from a zero position to avoid cumulative errors.

Machine has a 4-spindle, heavy-duty boring head mounted on a compound slide. Head contains boring spindle and three hydraulically positioned generating spindles with separate controls for three different feed rates. Ball-bearing screws are used for all feed motions. Indexing table is 55 in. in dia and driven by 1½-hp motor. Machine has automatic lubrication system with devices that warn operators of low oil level or faulty oil lines. Spindles are mist-lubricated and ways receive oil through a multi-valving system.

CERAMICS FROM GLASS GO COMMERCIAL

DR. J. H. MUNIER, *Manager, Product Development Dept. Research and Development Div. Corning Glass Works*

With experimental applications like ball bearings and pistons (above) showing promise, Corning Glass this week announced commercial production of two Pyroceram grades. Here's the latest on these new materials, with application data on the types available.

The Pyrocerams are moving up fast. It was only about four years ago that researchers first produced these opaque ceramics superior in many ways to their parent material–glass. Less than a year ago came the first developmental compositions. And now two commercial grades are in production that show promise of carrying these new ceramics into unusual fields:

Ball bearings, made entirely from Pyroceram and with standard equipment, are being evaluated by several manufacturers. Tests show they will operate at up to 1000 F with no lubrication–at loads to 50% of stainless-steel bearing capacity at this temperature. When the ceramic bearings do fail, it is apparently by gradual erosion, rather than by chewing action–an added advantage where sudden jamming of equipment cannot be tolerated. If present experimental work continues satisfactorily, and other bearing configurations prove out too, machinery that normally operates in the 500 F-plus area–turbines and pumps, for example–may be designed more simply in the not-too-distant future.

Pistons for diesel and internal-combustion engines are another intriguing possibility. A continuing problem in engine design has been the difference in thermal-expansion coefficient between piston and cylinder-wall

THERMAL SHOCK MATERIALS—COMPARISON OF PROPERTIES

	PROPERTY	PYROCERAM 9606	PYROCERAM 9608	PYREX 7740	HIGH-PURITY ALUMINAS
PHYSICAL	Specific gravity, 25 C	2.60	2.50	2.23	3.53–3.72
	Water absorption, %	0.00	0.00	0.00	0.00
	Porosity (gas permeability)	gas-tight	gas-tight	gas-tight	gas-tight
MECHANICAL	Modulus of elasticity (25 C), psi x 10^6	17.3	10–15	9.5	40
	Modulus of shear, psi x 10^6	6.9	5.0	4.0	——
	Modulus of rupture, psi x 10^3	26[a]	15–22[a]	5–7[a]	40–50
	Strength-weight ratio (M.R./S.G.), psi x 10^3	10.0	5.8–8.5	2.7	10.7–13.5
	Poisson's ratio	0.25	0.25	0.20	0.32
	Hardness (Knoop)	620 (500 gm)	600 (500 gm)	443 (100 gm)	——
THERMAL	Softening temperature, C	1350	1350	820	1700
	Max operating temperature, C (unloaded)	1000	1000	——	——
	(loaded, 1000 hr)	700	700	——	——
	Specific heat (25 C), cal/gm-° C	0.185	0.190	0.186	0.181
	(mean value, 25–400 C)	0.230	0.235	0.233	0.241
	Thermal conductivity (25 C), cal/sec-cm²-° C/cm	0.0087	0.0050	0.0026	0.056
	Thermal expansion coeff. (25–300 C), per° C x 10^{-6}	5.7	0.7–2.0[c]	3.2	7.3[b]
ELECTRICAL	Dielectric constant				
	(1) Frequency 10^6 cps				
	25 C	5.58	7.13	4.6	8.81
	300 C	5.60	(at 10^3 cps)	5.9	——
	500 C	8.80	6.84 (at 10^5 cps)	——	9.03
	(2) Frequency 10^{10} cps				
	25 C	5.45	not used	4.5	8.79
	300 C	5.41		——	——
	500 C	5.53		——	9.03
	Volume resistivity, $\log_{10}$ (ohm-cm)				
	250 C	10	8.1	8.1	14.0 (100 C)
	350 C	8.6	6.8	6.6	13.0 (300 C)

a Abraded values unabraded figures about twice as high
b Ranges: 20-500 C
c Depending on heat treatment

THERMAL GRADIENTS IN RESTRAINED PLATE

Surface stress in a restrained plate, caused by a steady-state temperature difference between the surfaces, can be calculated, independently of plate thickness, from the following equation:

$$\sigma = E\alpha\,\Delta t/2(1-\mu)$$

Problem: What is the max thermal gradient possible with Pyroceram 9606 as compared with 99+% alumina?

Symbol	Designation	9606	99+% Al_2O_3
S	Stress at rupture, psi	26,000	45,000
E	Elastic modulus, psi	17.3×10^6	40×10^6
α	Thermal coeff., °C	5.7×10^{-6}	7.3×10^{-6}
μ	Poisson's ratio	0.25	0.32
Δt	Temp. differential		

Substituting in the stress equation

For 9606: $\Delta t = 396$ C
For 99+% Al_2O_3: $\Delta t = 210$ C

materials, as well as corrosion by chemically active waste products. Using the converted glasses makes possible a close control over expansion coefficient. There is also their good mechanical strength, high hardness, and chemical resistance. Result is a spur to the design of new and unusual types of engines. Besides the integral piston shown in premachined form on p. 71, experimental aluminum pistons are being capped with Pyroceram to see if they will have additional corrosion resistance along with the desirable low-cost features of aluminum.

WHEN GLASS TURNS CERAMIC

Pyroceram is essentially a material that has been converted into a ceramic from its original glassy state by use of nucleating agents and carefully controlled heat treatment. About four years ago, it was discovered that adding these agents to a glass batch forms billions of submicroscopic crystallites throughout the glass body after it has been melted, formed and cooled. When the glass is reheated to proper crystallizing temperatures, each crystallite nucleus acts as a center for further crystal growth. Depending on original glass

composition and heat treatment, various degrees of crystallization are possible—thus creating a completely new non-glassy material.

This opaque ceramic has the same shape and size as the original glass article but is stronger and harder, has greater scratch and impact abrasion resistance, and is characterized by improved thermal and electrical properties. Although it has a liquidus-solidus phase diagram analogous to a metal-alloy system, Pyroceram is completely elastic and distinguished by having no ductility whatsoever. Nonetheless, appropriate compositions can withstand considerable thermal shock, compared with such other ceramic bodies as alumina and steatite. They cannot, however, be substituted directly for metals having the same nominal strength.

Glass-ceramics are about 50% harder than borosilicate glass, as measured by indentation tests. In their initial glass state, they can be readily ground to close tolerances by standard glass-finishing methods. Dimensional changes during heat treatment are small, at least for parts with reasonably uniform thicknesses. Distortional limits for parts with radically varying cross-sections, thick to thin, have not yet been determined. This problem is somewhat analogous to differential cooling in metal castings and, until careful design limits are set, the principles applying to castings —for example, liberal radii and gentle transition from thick to thin sections—should be observed.

As all Pyrocerams are transparent in the initial stages, they can be inspected visually for internal flaws before conversion to ceramic form. Glasses used are homogeneous and isotropic, assuring uniform thermal expansion of the glass-ceramic in all directions, important when minimizing thermal stresses in restrained parts. The materials are nonporous, show no weight increase after prolonged submersion in water, and can be finished to from 1 to 4 rms surface.

CHOICE OF GRADES

The glass-ceramics come in several grades and more are expected as development continues, needs are established, and the exact mechanism of nucleation is more clearly understood. Two grades—9606 and 9608—are now in commercial production; 9608 in the form of tubing, rod and sheet; 9606 in the form of cast parts.

Pyroceram 9606 was originally developed to give uniform electrical properties at microwave frequencies and at elevated temperatures for missile radomes. Other properties like high hardness and abrasion resistance make it a likely contender for such applications as a binding matrix for abrasive wheels, ball bearings, leading edges in hypersonic aircraft, and jigs for high-temperature brazing areas where specific projects are being considered.

With low viscosity, 9606 is most easily formed by gravity and centrifugal casting—techniques not generally associated with glass manufacture. With this easy-pouring characteristic, 9606 is expected to be applicable to complex parts using such precision casting methods as investment, lost-wax, Mercast, and Glascast (*PE—Oct. 14, '57, p. 68*). Here the similarities between the new glass-ceramics and ordinary metals are most striking, but the field is new to glass technology—and plenty of problems remain to be overcome.

Although 9606 can be sealed to metals by metallizing technique, or with a solder glass (*PE—Jan. '57, p. 188*), sealing temperatures is the key factor: If the setting point of the seal falls within the 425-C range, Kovar can be used. At setting temperatures of 750 C, however, tungsten fits the 9606 expansion curve closer and forms an effective seal.

Pyroceram 9608, on the other hand, is the general-purpose glass-ceramic—with wider range of viscosity and thermal expansion coefficient. Instead of casting, the conventional glass-forming methods are used: blowing, drawing, pressing and rolling. The principal industrial applications of 9608, at present, are concerned with heat exchanger tubing, piston heads (both attached and free-floating), poppet-type exhaust valves, bearings, and clutch facings.

The property ranges shown in the accompanying table do not mean that 9608 characteristics fall within these values, but rather that formulations having precisely and reproducibly controlled properties are available in the range indicated. Mechanical strength values shown are for abraded specimens, hence conservative. General glass design practice indicates that a safety factor of 6 should be applied to abraded values. Unabraded figure are about double those shown, and it is expected that, as more experience is gained with these new materials, lower safety factors will be permissible.

EFFECTS OF TEMPERATURE

Thermal stresses, particularly when a ceramic part is restrained, often cause more trouble than stresses from external loading. There is, unfortunately, no single factor which grades materials for resistance to thermal stresses. In fact, suitability of a given ceramic may be entirely reversed by changing the heat-transfer conditions from cooling in still air to water quenching.

Pyroceram's properties allow it to take considerable thermal shock—as shown by performance of missile radomes and heat-exchanger tubing. But each case must be studied carefully before final geometry of the part is established. In both steady-state and transient applications, the glass-ceramics allow increased thermal gradients over many established ceramic bodies. A simple example is shown in the calculation on the opposite page for plate material restrained from bending, as in a cylinder or radome structure.

EDITOR'S NOTE: Properties of other high-temperature ceramics and cermets are covered in these recent articles:

"Ceramics That Bounce," Feb 3, '58, p 76, shows how high-purity alumina in sintered spring form can give elastic action up to 2000 F.

"Titanium Carbide," Nov 11, '57, p 84, discusses a family of materials suitable for precision parts that require oxidation resistance and hot strength above 1600 F.

"New Low-expansion Ceramic," Sept 30, '57, p 70, covers an addition to the aluminum-silicate family with properties suitable for thermal shock applications.

"Nitride-bonded Silicon Carbide," Feb '57, p 135, shows how to design parts for resistance to high-temperature corrosion and abrasion. Applications covered include a refractory pump for handling molten aluminum.

this method simplifies . . .

INPUT-OUTPUT ANALYSIS of MECHANISMS

JOHN O. PREDALE

Associate Professor of Mechanical Engineering
Newark College of Engineering

It's called the principle of virtual work. It gives rapid, accurate answers to problems involving troublesome torque ratios. With diagrams and sample problems, the author shows how.

Here is a time-saving method for applying the principle of virtual work to the dynamic analysis of mechanisms. It will find accurately the relationship between input and output torques—which is a basis for matching a motor with a load, designing flywheels to reduce output fluctuations, analyzing the system for natural frequencies, and determining stresses in linkages. The method is especially helpful where the torque relationship is complicated by inertial forces of moving links. It does away with need for constructing a free-body diagram for each link of the mechanism and is more accurate than the energy method, which neglects the weights of the links.

WHAT IS VIRTUAL WORK?

As with the free-body concept, virtual work is a way of stating conditions of equilibrium in a system. Although not a common method, it is used to find force reactions in static structures such as beams. In this article, the same method is extended to solution of problems involving machines or mechanisms in motion.

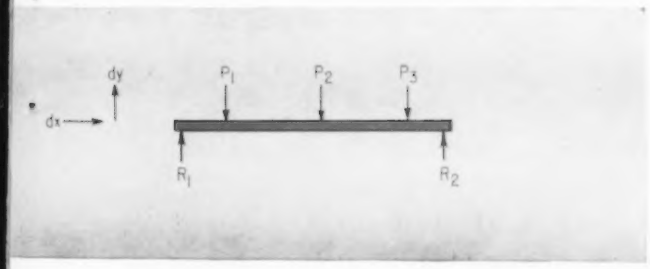
Virtual work is best illustrated with a simple beam problem. Imagine the beam in Fig. 1 being displaced an infinitesimal amount d_y by a fictitious outside force. The fact that the beam may be restrained from moving does not matter—neither does the magnitude of the fictitious force. Virtual work is the product of a real force on the beam multiplied by its respective imaginary displacement (called "virtual" displacement). The principle states that if the beam is in equilibrium, the total virtual work performed by all the forces is equal to zero. Thus

$$R_1 d_y + R_2 d_y - (P_1 + P_2 + P_3)\, d_y = 0$$
$$\text{or } R_1 + R_2 - P_1 - P_2 - P_3 = 0$$

Although this only shows that the summation of all forces in the y direction is equal to zero, if one of the forces or reactions was not known, the method would help find it.

There are certain rules in using this principle:

- It is assumed that the beam is a rigid member—its real deflections caused by the loads are disregarded.
- Displacements, though fictitious and infinitesimal, are represented by vectors drawn to some convenient scale.
- Forces perpendicular to the plane of the beam need not be considered, even if they did exist, because the given supports are assumed adequate to resist them.



1 Structural members . . .
can quickly be analyzed for load distribution by applying a fictitious or "virtual" displacement dy, and summing the work performed.

• The beam can be analyzed for as many degrees of freedom as desired—two degrees in the above case.

With linkages it may be more expedient to apply an angular virtual displacement than a linear translation. For example, the link in Fig. 2 (A) is restrained from moving in any direction. Its free-body diagram is shown in (B). Now if some outside force produces an infinitesimal angular displacement $d\beta$ about an arbitrary axis Q normal to the plane of the bar, the instantaneous displacement pattern of selected points will then appear as shown in (C).

Points falling outside the boundary of the bar are still considered part of the bar. Each point will have a displacement vector with magnitude proportional to distance from axis to the point, thus $d_i = R_i\, d\beta$, where subscript i represents the relationship at any point. Directions of the displacements will be compatible to the direction of $d\beta$.

The displacements, though fictitious, are treated as vectors. It is also assumed that the real forces remain constant in magnitude and direction. This leads to the concept of virtual work as a scalar (or dot) product of force and associated virtual displacement:

$$\bar{P}_i \cdot \bar{d}_i = P_i d_i \cos \gamma_i$$

where γ_i is the angle between the directions of $\bar{P}_i$ and $\bar{d}_i$ and the bars over the letters denote vector properties.

Total virtual work performed is

$$\sum_{i=A}^{E} \bar{P}_i \cdot \bar{d}_i = \sum_{i=A}^{E} P_i d_i \cos \gamma_i$$

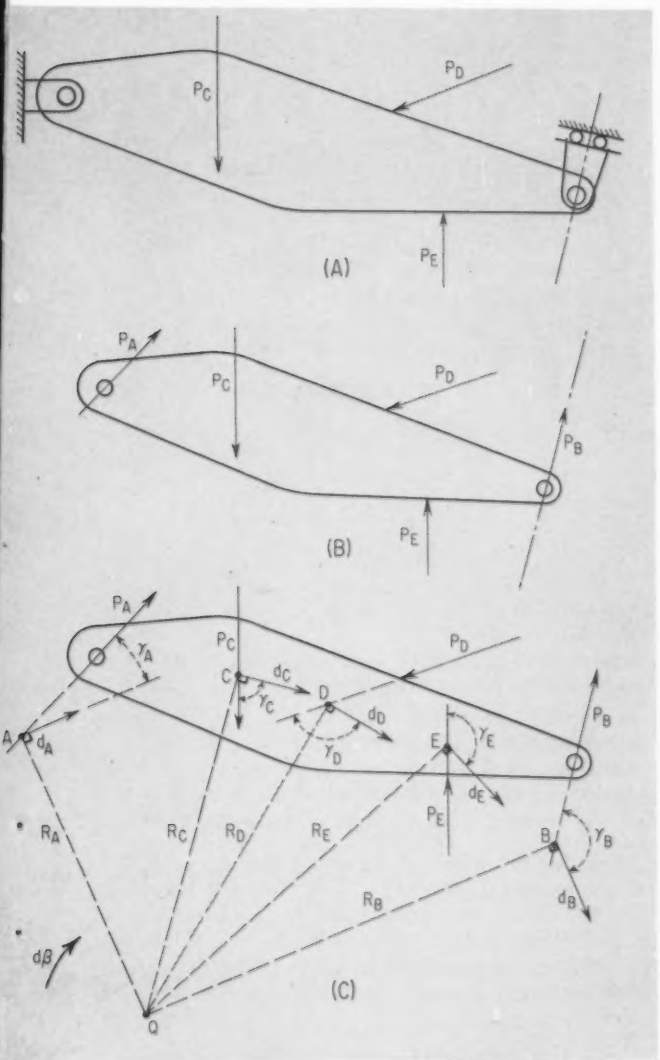
Thus for a system in equilibrium, with friction assumed negligible, the total virtual work performed by all forces external to the system is equal to zero for any virtual displacement patterns:

$$\sum_{i} P_i \cdot d_i = 0$$

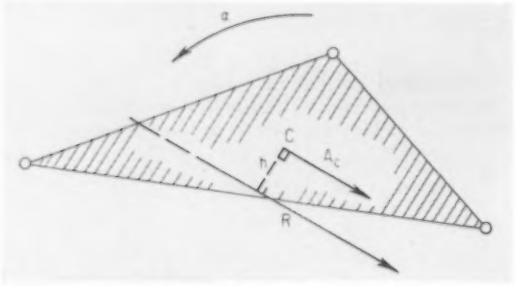
Reaction forces of the supports are included in the summation unless for a given virtual displacement pattern they produce no virtual work.

DYNAMIC EQUILIBRIUM

Main difference between a static system, such as the beam and link restrained from moving, discussed above, and a dynamic system such as a four-bar linkage in motion, is that the linkage develops inertial forces caused by changes in velocity of the links (this occurs



2 Forces acting on a rigid bar . . .
(A) The bar is constrained against all motion. (B) Free-body diagram of bar shows support reactions P_A and P_B. (C) Instantaneous pattern associated with an angular virtual displacement $d\beta$.



3 Link in motion . . .
develops a resultant force *R* whose direction, magnitude and location must be balanced beforce a dynamic analysis can be made.

even if the driving link is rotating with constant velocity). The principle of virtual work cannot be applied to a system unless the system is in equilibrium. Therefore a linkage in the state of motion must be transformed to a state of "dynamic equilibrium." This is accomplished by finding, and introducing to the force diagram of each link a hypothetical force which will balance the real forces.

The resultant force acting on a link in Fig. 3 moving in plane motion can be established from the following

$$R = mA_c \quad (1)$$

$$M_c = I_c\alpha \quad (2)$$

where

R = vector sum of all forces acting on the link, lb
m = mass of the link, slugs
A_c = vector acceleration of the center of mass C of the link, ft/sec²
M_c = resultant vector moment of all forces and couples acting on the link with respect to an axis passing through the mass center, lb-ft
I_c = mass moment of inertia of the link about an axis through its mass center, slug-ft²
α = vector angular acceleration of the link, radians/sec²

From a vectorial standpoint, the equations state that R and mA_c have the same magnitude and direction, but that the position of mA_c may be quite different from that of R. Vector mA_c is located at the mass center of the link whereas vector R, in general, does not pass through the mass center.

All forces, displacements, velocities and accelerations are treated as vectors. This means that vectorial rules apply when adding, multiplying, etc.

To establish the position of R, Eq (2) is divided by Eq (1), resulting in

$$h = \frac{M_c}{R} = \frac{I_c\alpha}{mA_c} \quad (3)$$

where h is distance in inches from mass-center axis to line of action of R. Rotational sense of R about C must be the same as the direction of α.

Accelerations α and A_c are determined from a kinematic analysis of the mechanism containing the link. The location of mass center C and quantities m and I_c are computed from dimension of the link.

If force R is balanced by a fictitious force F_i, the link would be in dynamic equilibrium. The force is commonly referred to as inertia force and can be found from:

$$F_i = -mA_c \quad (4)$$

$$M_i = -I_c\alpha \quad (5)$$

where M_i is the vector moment of F_i with respect to the mass-center axis.

Forces F_i and R have the same magnitude and line of action but opposite directions. Force F_i can now be established using these steps:

1. Determine the magnitude and direction of F_i from Eq (4).
2. Compute h from Eq (3).
3. Position F_i in accordance with Eq (5).

By assuming F_i to be a real force applied to the link, R is equilibrated, thereby reducing the state of motion of the link to the state of dynamic equilibrium. This transformation, known as d'Alembert's principle, is a key factor in the dynamic analysis of mechanisms.

The over-all virtual-work contribution of the forces in the link joints is zero because friction in the system has been ignored.

Time and effort can be saved by choosing a virtual-displacement pattern which is compatible with the geometric restraints of the mechanism. One rule to keep in mind is that a force acting perpendicular to its associated virtual displacement does no virtual work.

FOUR-BAR LINKAGE ANALYSIS

Here is how the principle of virtual work is applied to a four-bar linkage to find the relationship between input torque T_2 and output torque T_4 for the position shown in Fig 4 (A). Known data are:

Link lengths, ft

$DE = 1.25$ $DA = 0.5$ $AB = 1.5$ $BE = 1.0$

Link weights, lb

$W_2 = 9$ $W_3 = 18$ $W_4 = 15$

Mass-center location, ft

$DC_2 = 0.25$ $AC_3 = 0.7$ $EC_4 = 0.4$

Mass moments of inertia, slug-ft²

$I_{C2} = 0.032$ $I_{C3} = 0.285$ $I_{C4} = 0.101$

Input link motion

angular velocity $\omega_2 = 10$ rad/sec
angular acceleration $\alpha_2 = 20$ rad/sec²

SOLUTION

1. Construct the velocity polygon of joints A and B, and mass centers C_2, C_3 and C_4. This is done in Fig. 4 (B). The dotted vectors and points q_2, q_3 and q_4 refer to the final phase of the problem. Briefly, here is how the velocities are found (other methods for finding the velocities can be employed if desired).

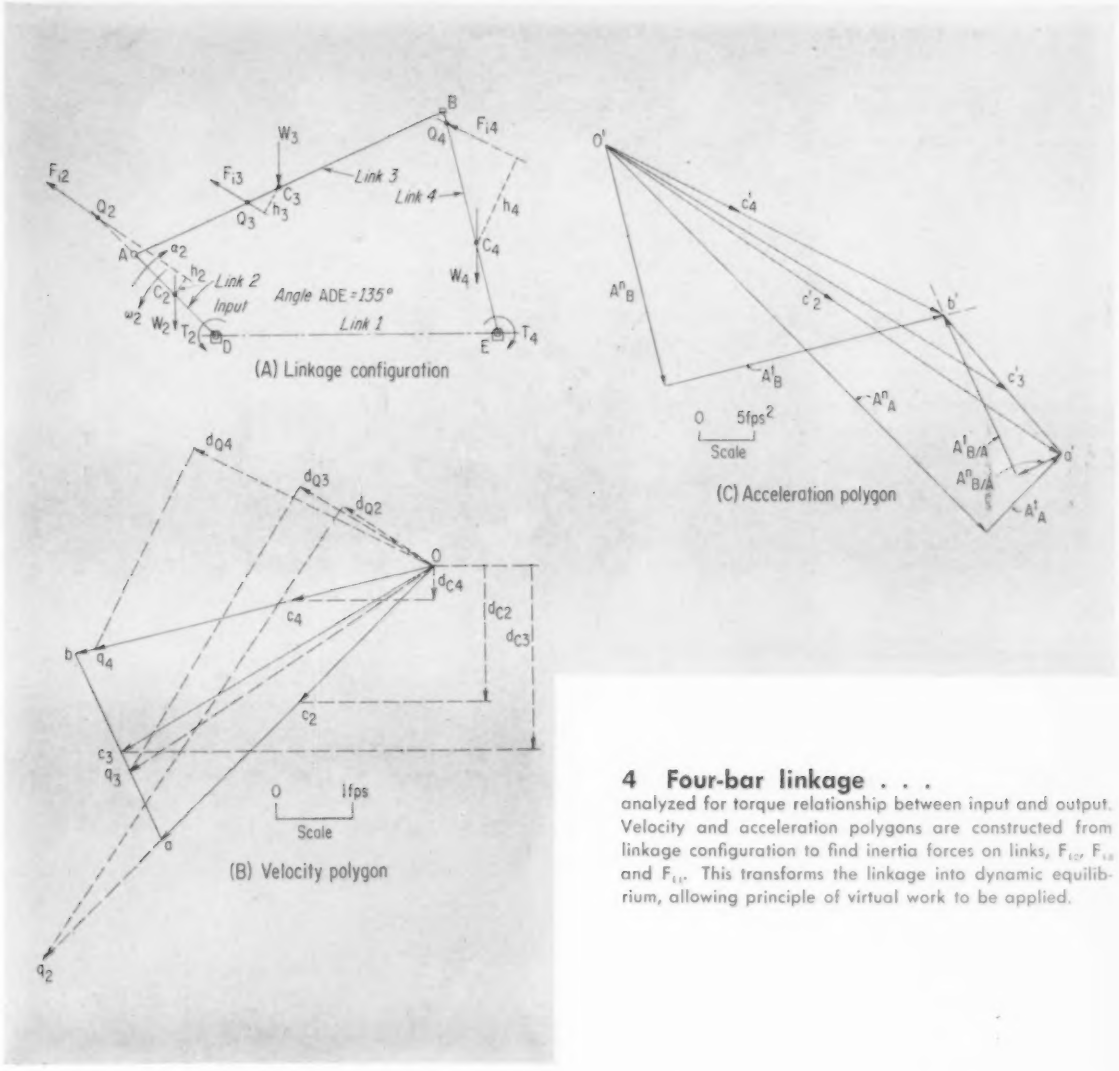
Velocity of point A is:

$$V_A = \omega_2 (AD) = 10\ (0.50) = 5 \text{ fps}$$

Vector V_A is then represented by line oa to the scale indicated. Vector V_B is established from the vector equation

$$V_B = V_A + V_{B/A}$$

where $V_{B/A}$ is the relative velocity of point B with re-



4 Four-bar linkage . . .
analyzed for torque relationship between input and output. Velocity and acceleration polygons are constructed from linkage configuration to find inertia forces on links, F_{i2}, F_{i3} and F_{i4}. This transforms the linkage into dynamic equilibrium, allowing principle of virtual work to be applied.

spect to point A. The vector addition is usually performed graphically.

Points c_2, c_3, and c_4 are located by utilizing the geometric similarity between the velocity image of a link and the figure formed by the link and its absolute instantaneous center of velocity. Taking the case of c_3:

$$ac_3 = ab\,\frac{AC_3}{AB}$$

Thus ω_2 (for link 3) = 2.65/1.5 = 1.77, and ω_4 = 4.76/1 = 4.76 rad/sec.

2. **Construct the acceleration polygon**, diagram (C), from the velocity polygon. Briefly, the normal acceleration of point A is equal to

$$A_A{}^n = \omega_2{}^2\,(AD) = 50\,fps^2$$

Tangential acceleration of point A is equal to

$$A_A{}^t = \alpha_2\,(AD) = 10\,fps^2$$

Resultant acceleration of point A is then determined from the vector equation

$$A_A = A_A{}^n + A_A{}^t$$

This is represented by vector o'a' to scale indicated. Normal acceleration for point B is:

$$A_B{}^n = \omega_4{}^2\,(BE) = 22.7\,fps^2$$

Normal acceleration of point B relative to point A is:

$$A_{B/A}{}^n = \omega_3{}^2\,(AB) = 4.68\,fps^2$$

Point b' is then established from the equation:

$$A_B{}^n + A_B{}^t = A_A + A_{B/A}{}^n + A_{B/A}{}^t$$

where $A_B{}^n + A_B{}^t = A_B$

and $A_{B/A}{}^n + A_{B/A}{}^t = A_{B/A}$

Vector a'b' represents $A_{B/A}$ and o'b' represents A_B.

As in the case of the velocity polygon, points c'_2, c'_3 and c'_4 may be located by proportion because the acceleration image of a link is similar to the figure formed by the link and its instantaneous center of acceleration. Point c'_3, for instance, is established from the equation

$$c'_3b' = a'b'\,\frac{C_3B}{AB}$$

By completing the acceleration polygon, the follow

ing values may be scaled:

$$A_{c2} = 25.5,\ A_{c3} = 43.4,\ A_{c4} = 14.0$$

$$A_{B/A'} = 16.1 \text{ and } A'_B = 26.7$$

Angular acceleration magnitude of link 3 is

$$\alpha_3 = \frac{A_{B/A'}}{AB} = \frac{16.1}{1.50} = 10.73 \text{ radians/sec}^2$$

and α_3 is found to be counterclockwise in accordance with the direction of $A_{B/A'}$.

Similarly, $\alpha_4 = 26.7$ radians/sec^2 and is established as clockwise.

3. Compute the inertia force magnitudes and h-distances using the scaled values of acceleration and Eqs (3) and (4). Thus

$$F_{i2} = m_2 A_{c2} = \frac{9}{32.2}\ (25.5) = 7.13 \text{ lb}$$

$$h_2 = \frac{I_{c2}\alpha_2}{F_{i2}} = \frac{0.032(20)}{7.13} = 0.09 \text{ ft}$$

Similarly, $F_{i3} = 24.3$, $F_{i4} = 6.52$, $h_3 = 0.126$, $h_4 = 0.414$.

4. Locate the inertia forces F_i in the configuration diagram, Fig. 4 (A). Forces need not be drawn to scale as long as they are h distances away from points C. Directions are opposite to accelerations c'_2, c'_3 and c'_4.

Diagram now shows the mechanism in a state of dynamic equilibrium. The reaction forces at the supports D and E are missing, but as they produce no virtual work they may be excluded.

5. Use the velocity polygon as a virtual displacement polygon. Assume that the mechanism undergoes an infinitesimal movement compatible with its geometric constraints. The solid and dotted vectors in diagram (B) now comprise the instantaneous virtual displacement polygon. The point at which a virtual displacement vector is localized is arbitrary except for the restriction that the point must lie on the line of action of the associated force. In the present problem each virtual displacement vector is localized at the point where the line of action of the associated force and link (or link extended) intersect in diagram (A). This locates points Q_2, Q_3 and Q_4. The image points q_2, q_3 and q_4 are found by proportion and entered into diagram (B). For example, proportion $Q_2D{:}AD$ in diagram (A) is equal to proportion $q_2o{:}ao$ in diagram (B).

6. Find the work-producing displacement vectors by resolving in diagram (B) each virtual-displacement vector into two orthogonal components; one along the line of associated force and the other perpendicular. The work-producing components are identified by the letter d; choice of scale and unit of length are arbitrary. The scaled values in inches are:

$$d_A = oa = 5.0,\ d_{C2} = 1.78,\ d_{Q2} = 1.40,\ d_{C3} = 2.40,$$
$$d_{Q3} = 2.0,\ d_{C4} = 0.45,\ d_{Q4} = 3.44,\ d_B = ob = 4.76$$

7. Sum up the virtual work. Each virtual displacement is multiplied by its associated force or torque. The total is equal to zero. Plus sign is used if displacement and force have the same direction. Thus:

$$\frac{T_2}{AD}\ d_A + W_2 d_{C2} + F_{i2} d_{Q2} + W_3 d_{C3} + F_{i3} d_{Q3}$$
$$+ W_4 d_{C4} + F_{i4} d_{Q4} - \frac{T_4}{BE}\ d_B = 0.$$

Substituting the correct values gives:

$$\frac{T_2}{0.50}\ (5.0) + 9(1.78) + 7.13\ (1.40) + 18(2.40) +$$
$$24.3(2.0) + 15(0.45) + 6.52(3.44) - T_4(4.76) = 0,$$

from which

$$T_4 = [30.9 + 2.1\ T_2 \text{ lb-ft} \qquad (6)$$

The assumed directions of T_2 and T_4 are valid because their magnitudes in Eq (6) are positive.

This method can also be employed to analyze mechanisms involving Coriolis' acceleration and slider cranks to find relationship between input torque and resisting force, provided that the elements may be considered as rigid bodies and frictional effects can be neglected.

EDITOR'S NOTE: A systematic method for finding the relationship between input and output torques in a gear system, "Speed-torque Analysis for Rotating Mechanical Systems," has been presented in two parts: Part I—Dec '56, p 184; Part II—Feb '57, p 179.

A new German method now applies the simplicity of cam diagrams to design of four-bar linkages. For details, and a summation of advantages and limitations, see "Linkages Gain on Cams," Dec 23 '57, p 75.

Watch for the March 31 issue—

It includes—in separable pamphlet form—your personal guide to the Design Show and Conference at Stock Yards Amphitheatre in Chicago, April 14-17.

In addition, the editors have prepared a special report entitled,

The Engineer Comes Into His Own

consisting of twelve feature articles, each examining the new, more-responsible role of the engineer in a changing society.

What is the status of engineering education, both undergraduate and graduate? How is industry encouraging high-school students as well as working engineers?

How is the Federal government helping and hindering research development, and design?

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Watch for *The Engineer Comes Into His Own* in the March 31 issue of PRODUCT ENGINEERING.

why it pays to depend

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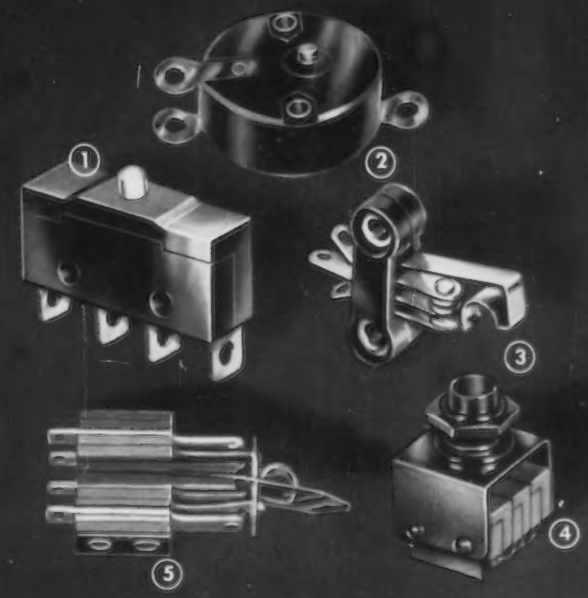

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Use your own housing—even include other components if you desire—with this unique precision switch. Readily adapts to return or set type operation. Actuator may be insulated or extended to meet requirements. Many other combinations are possible.

4 PUSH BUTTON SUBMINIATURE

Three split contact circuits in subminiature size. Only 25/32" long by 55/64" wide by 1 13/64" high. Rated at 10 amps—115 volts A.C. This panel mounted, overtravel plunger-type actuator assembly is believed to be the smallest yet made.

5 OPEN BLADE MULTI-POLE SUBMINIATURE

Recommended for economical and positive control of two circuits. Laminations are secured by two eyelets which provide holes for mounting screws. Available in return or set type with rear or side terminals.

ACRO Subminiature Switches

Compare the ACRO group of Subminiature Switches any way you like—cost, performance, size, capacity, versatility—you'll see why more and more design engineers are specifying ACRO.

These five basic types of subminiature switches offer many development possibilities for your subminiature assemblies . . . from aircraft applications to vending machines. All incorporate the patented rolling spring action for which ACRO Switches are internationally known and respected.

ACRO's modern mass-production techniques and facilities assure lowest possible unit cost . . . even when variations of basic switches are required to meet your specific needs.

Talk over your requirements or possibilities with an ACRO engineer . . . or write for engineering data on any or all of the five subminiature switches shown here.

Mr. Controls

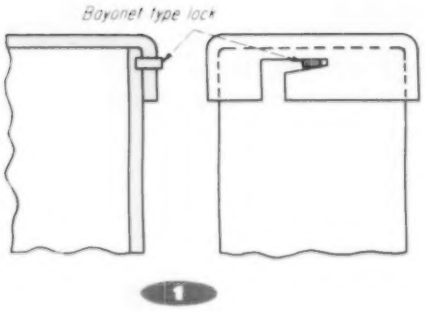
Robertshaw-Fulton CONTROLS COMPANY

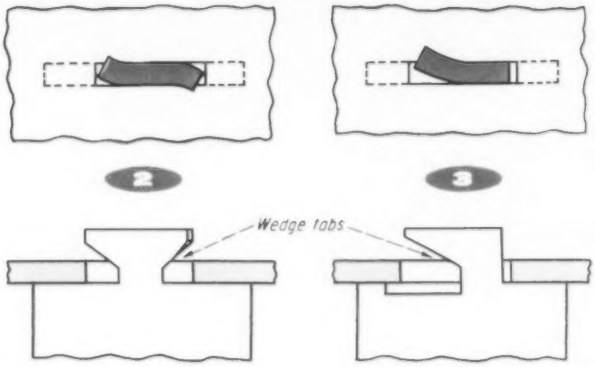
ACRO DIVISION Dept. 113, Columbus 16, Ohio

In Canada: Robertshaw-Fulton Controls (Canada) Ltd., Toronto

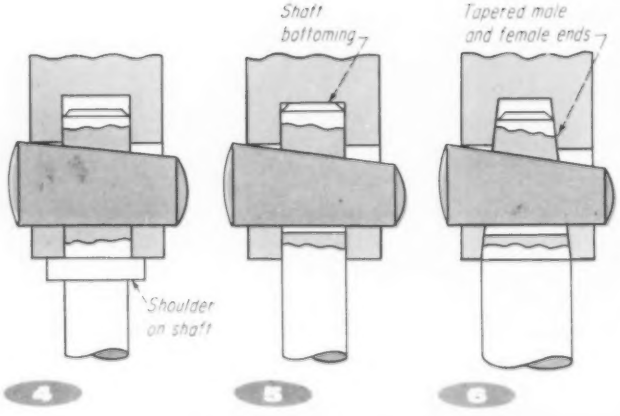
17 Wedge-action Assemblies

for temporary or semi-permanent assembly

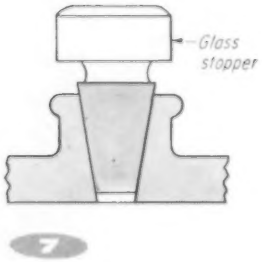


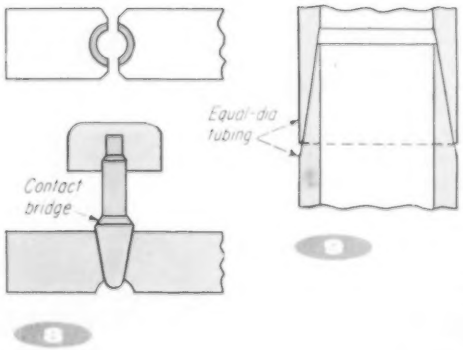


Bayonet-lock and tabs . . .
provide quick, reliable assembly of metal lids. Container must be circular-shaped for bayonet lock. In twisted-tab assemblies (2, 3) wedge action of tabs makes assembly stronger.



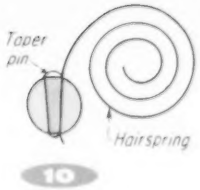
Transverse flat wedge . . . ▶
is quick, low-cost method of making in-line connections, usually for shafts or spindles. Common feature of all three fastenings is that entry of male part into female is limited to allow wedging action.





Direct assembly of two workpieces . . .
is typified by ground-glass stopper (7), contact bridge in electrical resistance-box (8), and tubing joint (9) where tubes have same dia.

FEDERICO STRASSER
Santiago, Chile



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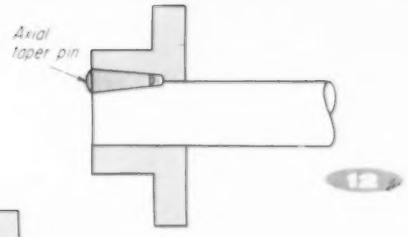

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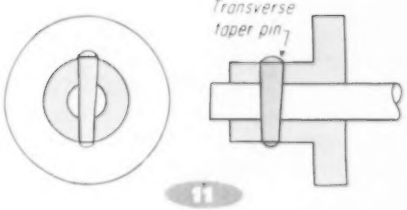
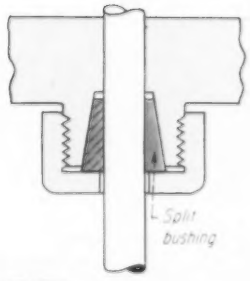


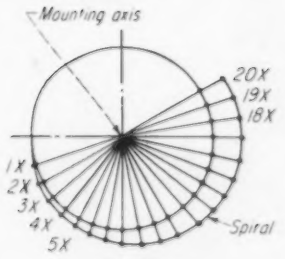
11

Taper pin . . .
makes satisfactory fastening by joining hairspring in hole (10). Taper pin is ideal for other, similar fastenings. Gear-wheel hubs are quickly fastened to shafts by (11) transverse or (12) axial pins.



13

Split taper-bushing . . .
allows rod to be adjusted to any axial position. Bushing and rod should have sliding fit. If too much clearance is provided, however, bushing may not clamp tightly enough for good grip on rod, which could then slip.



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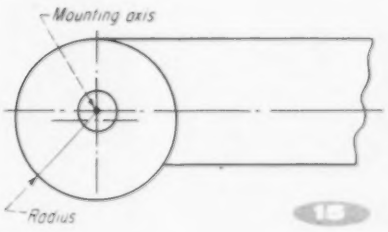

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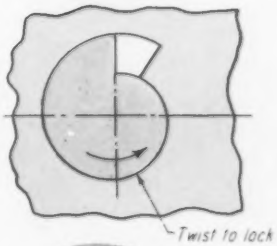

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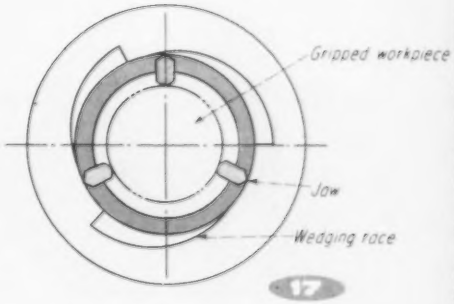


17

Best shape for eccentric . . .
is an Archimedean spiral (14). However, the simpler, less-expensive design (15) has a circular disk with an off-center axis. Eccentric can be formed directly on one of workpieces (16), with fastening made by relative rotation of the two parts. Three-jaw chuck (17) is actuated by wedging action of jaws against inclined races of outer ring.

A famous name in rubber and steel
strikes a colorful new note in aluminum!

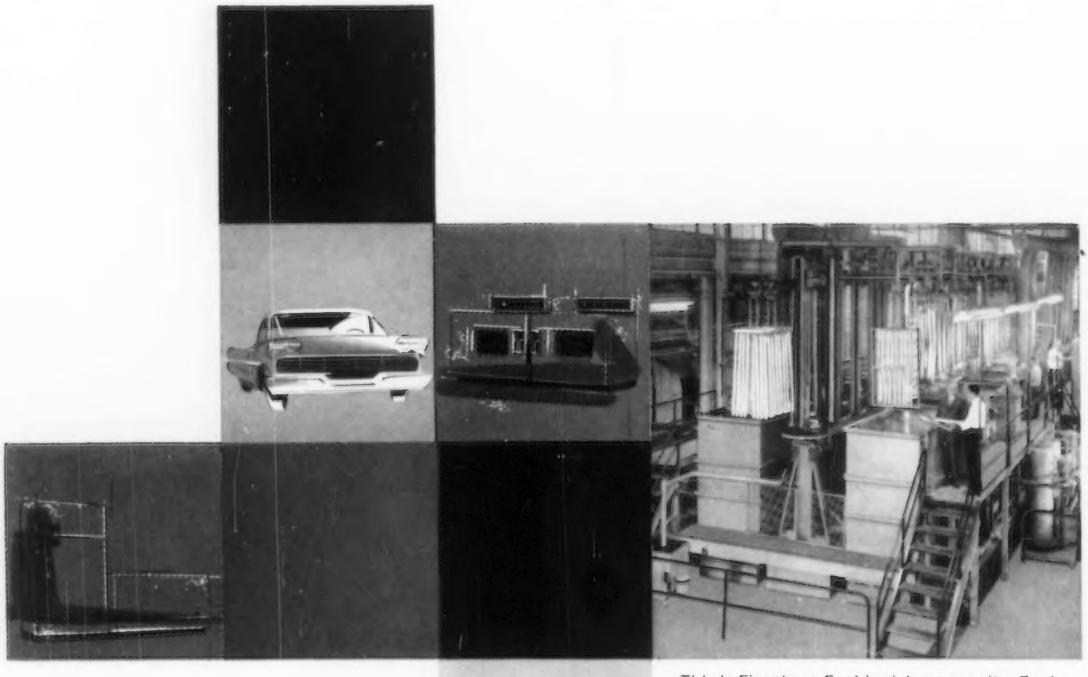
FIRESTONE *now producing*

fashionized aluminum

color-anodized parts and trim for automotive products and home appliances

Already brightening everything from cars to kitchens! Fashionized aluminum—from Firestone's huge new fabricating facility. Most completely automated in the industry, it combines Firestone's 50 years of experience in metal fabrication with its demonstrated understanding of a colorful new medium and its countless trim possibilities. It can meet your most exacting specification for Fashionized aluminum—from texture to tint, design to delivery date—in mass-produced part sizes up to seven feet long. Your inquiries, your inspections and your cost comparisons are cordially invited. Write, phone or wire today for full information about Fashionized aluminum.

FIRESTONE STEEL PRODUCTS COMPANY, AKRON 1, OHIO



This is Firestone Fashionizing capacity. Each of these anodizing racks can easily process a full 120 square feet of aluminum at one time!

REFERENCE BOOK SHEET

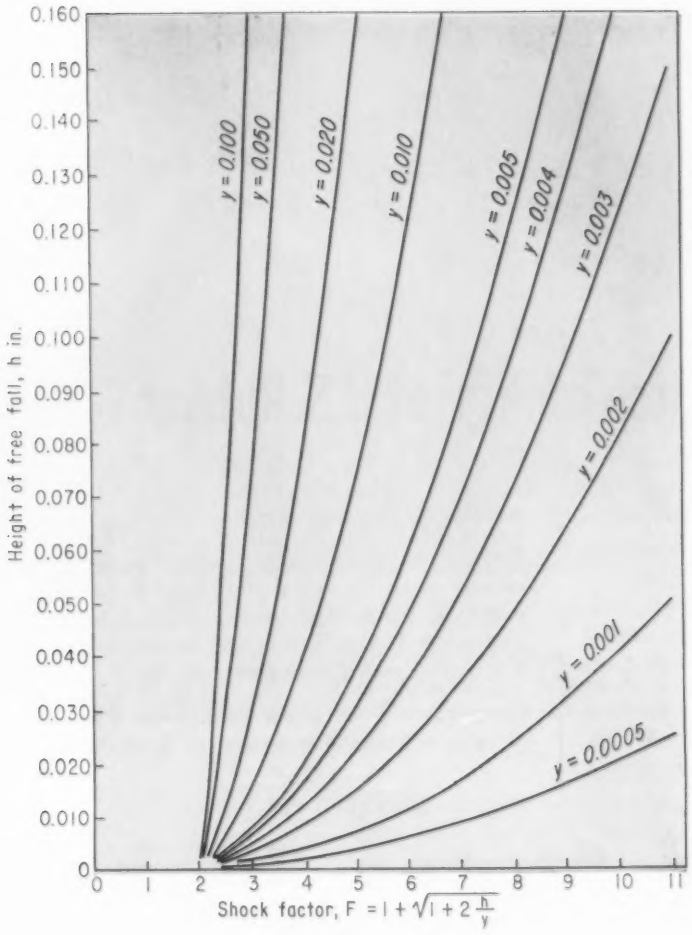
SHOCK FACTORS for IMPACT LOADS

proper design must consider cushioning and stress distribution

GLEN H. HOWELL

Professor of Mechanical and Industrial Engineering, Wayne State University, Detroit

Weaker supports may be better than stronger ones under impact. Charts show what factors apply.



High impact speeds do not always cause high shock loads. If structure deflection rate under a static load is low, the shock will be "cushioned," hence shock factor will be low. Stiffer structures cause higher shock loads, therefore, may even turn out to be less suitable for certain conditions than weaker supports.

The following formula can be used, generally, for finding shock factor F for an impact load caused by a falling weight:

$$F = 1 + \sqrt{1 + 2h/y}$$

where h is distance of free fall, in., y is deformation, in., that would occur if falling weight were applied statically.

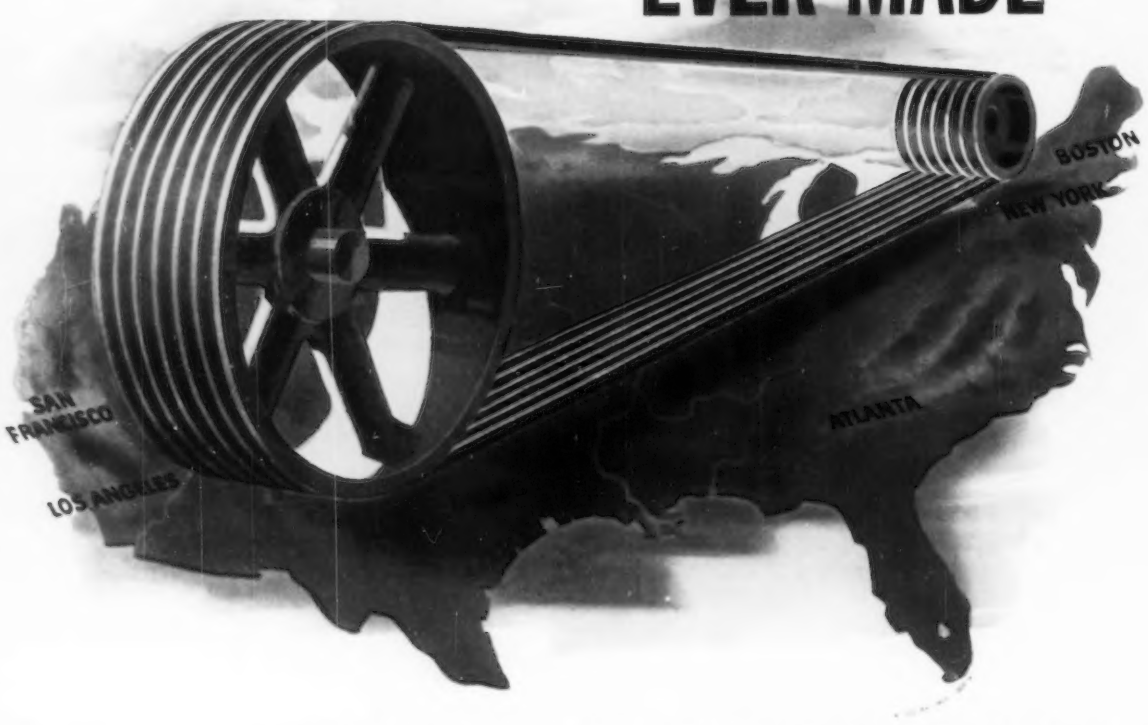
(continued on page 101)

Free-fall shock factors . . .

calculated for various static deflections and free-fall heights. Static deflection is that which would be caused if the falling weight were applied slowly.

US RUBBER V-BELTS

MOST DARING TEST OF ITS KIND EVER MADE



Proves unequaled "match-ability" of U.S. Rubber V-Belts

We wanted to see what climate and what age might do to U.S. Rubber V-Belts. Would they still match?

Sticking our chin out, we picked at random—right from stock (and without measurement)—a size C-144 U. S. Rubber V-Belt from each of six different cities across the country. Each belt was shipped in a sealed carton which was not opened until the six were put on a single drive.

Result: *All six belts matched.*

And to prove this was no accident, we performed the same test with hundreds of U. S. Rubber V-Belts. Again, the matching was flawless.

You may never have to put your V-Belts to such an extreme test of "match-ability", but it is good to know that U. S. Rubber's method of building belts—up to 15 feet—and other engineering advances, assure you of a perfect match, *anywhere, any time.*

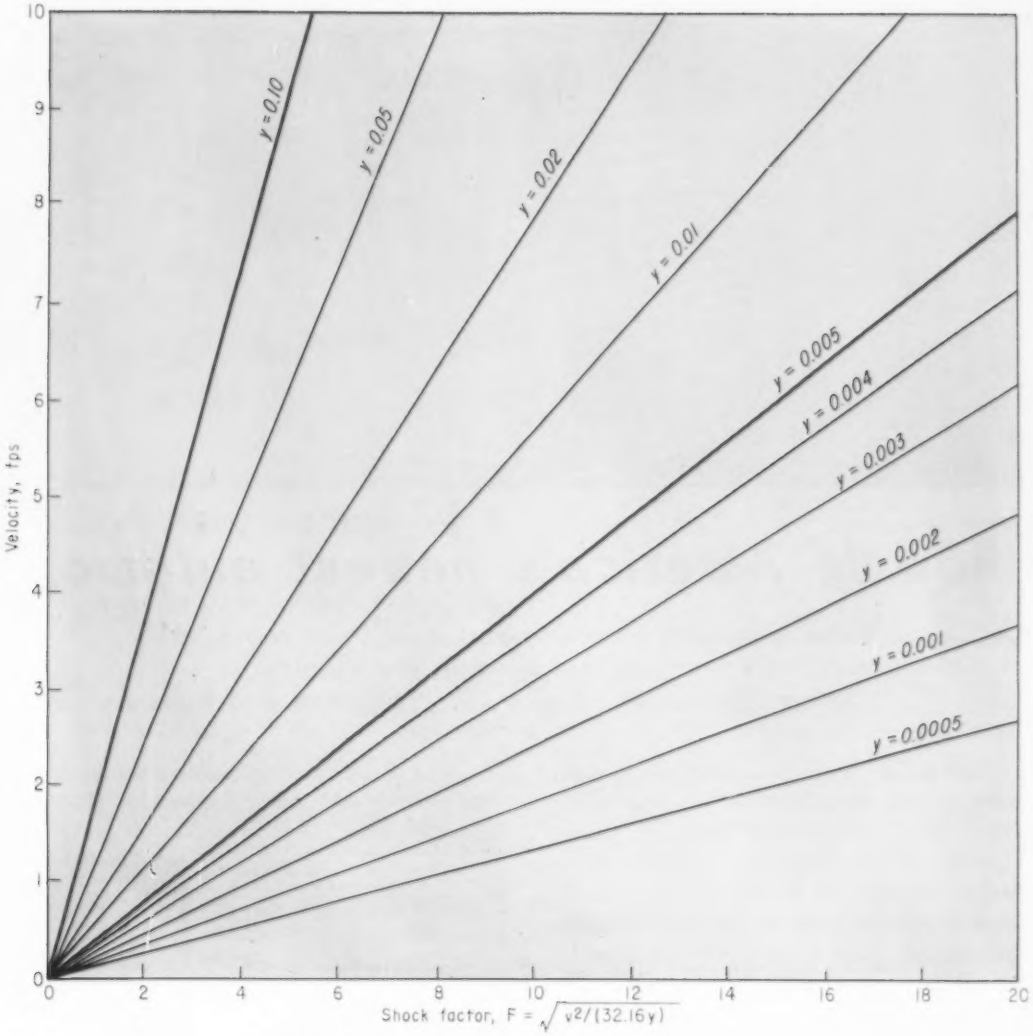
Contact any "U. S." power transmission distributor, or write us at Rockefeller Center, N. Y. 20, N. Y.

Mechanical Goods Division

United States Rubber

See things you never saw before. Visit U. S. Rubber's new Exhibit Hall, Rockefeller Center, N. Y.

SHOCK FACTORS for IMPACT LOADS *concluded*



Velocity shock factors . . .

calculated for same static deflections as in first chart, but for a specific velocity instead of free fall.

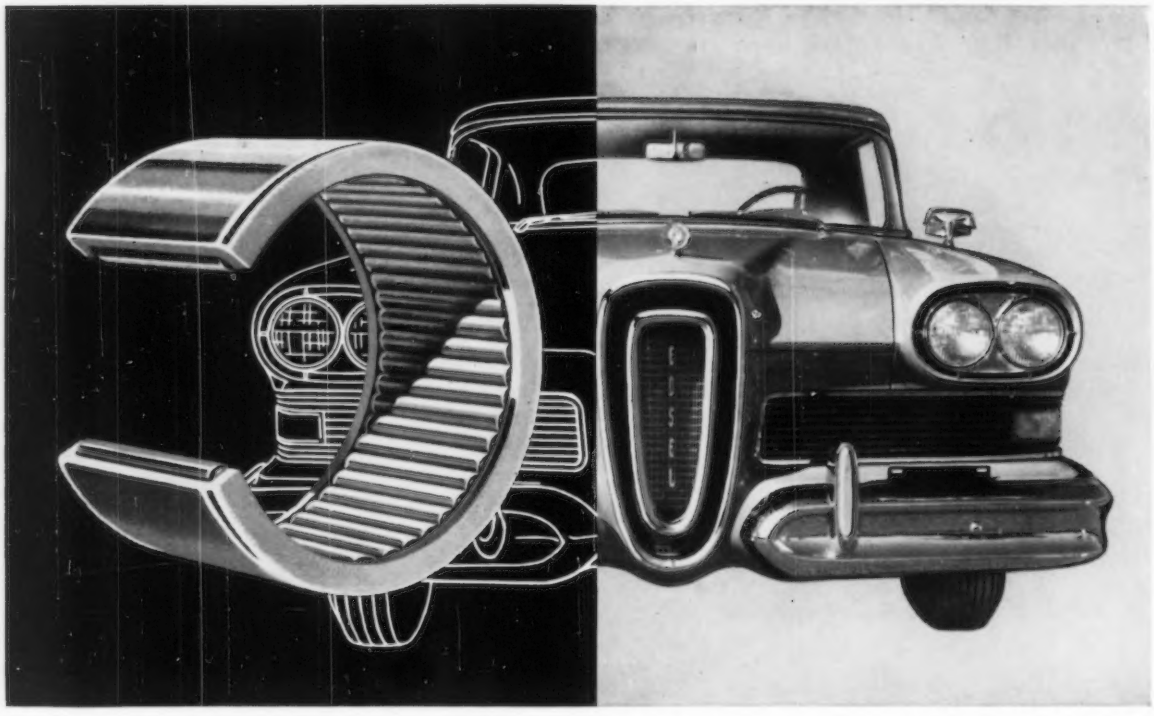
In terms of velocity v, fps, independent of direction

$$F = \sqrt{V^2/(32.16y)}$$

Deflection and stress that would be caused by the impacting load if it were applied statically, multiplied by the shock factor, gives deflection and stress resulting from the impact.

Designs for impact loadings should have stresses distributed as evenly as possible throughout the material. Accordingly, notches, holes, etc., that increase stress concentrations should be kept to a minimum. Structure mass is assumed to be less than impact mass.

America's newest thin-shell needle bearing



. . . now in America's newest automobile

Developed with the cooperation of Ford Motor Co., these KAYDON bearings are used in the automatic transmissions of Edsel as well as Ford and Mercury

The 1958 Edsel, America's newest automobile, backed by more than 1,250,000 road-test miles, employs in its transmission, America's newest thin-shell needle bearings, introduced by Kaydon of Muskegon. Why?

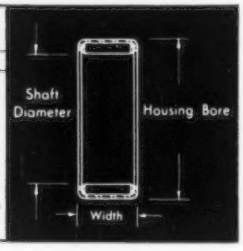
Proven in Ford-O-Matic and Merc-O-Matic transmissions, these Kaydon thin-shell needle bearings deliver 46% more bearing capacity.

Greater effective length of spherical end rollers does it. Important too, simplified construction, pre-packed lubrication, saves money . . . and saves valuable time on the assembly line too! See table below for standard Kaydon thin-shell needle bearing sizes.

AVAILABLE FROM STOCK IN 5 STANDARD SIZES:

SHAFT DIAMETER	HOUSING BORE	WIDTH
1.0605"	1.3130"	.500"
1.1250"	1.3755"	.750"
1.1250"	1.3755"	1.000"
1.1875"	1.5005"	.625"
1.3750"	1.6875"	.625"

For other sizes and complete specifications, write or call KAYDON of Muskegon today.



THE KAYDON ENGINEERING CORP.

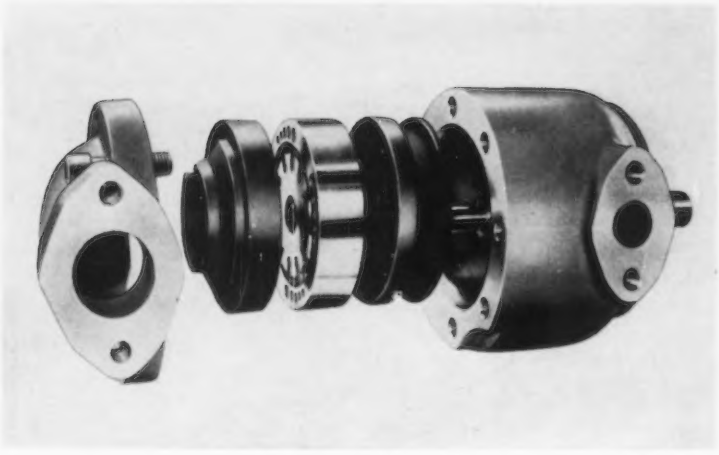
MUSKEGON • MICHIGAN

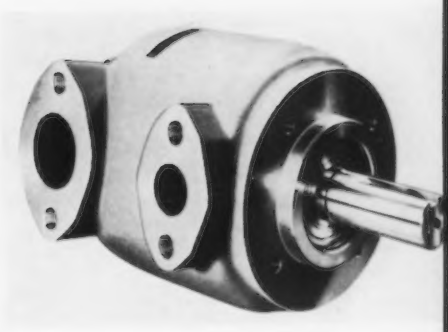
K-573

All types of ball and roller bearings — 4" inside diameter bore to 160" outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Needle Roller • Ball Radial • Ball Thrust Bearings

NEW COMPONENTS and MATERIALS





Balanced-vane Pump for 2000-psi Hydraulic Service

These pumps are based on a design that leaves the vanes open to pressure on the pressure stroke, and to suction on the suction stroke. This series of pumps was developed for trucks, earthmoving equipment and industrial machinery.

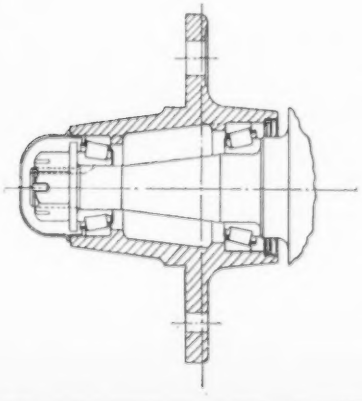
Models capable of supplying up to 100 gpm at speeds up to 1800 rpm are produced. They are available with either clockwise or counter-clockwise shaft rotation. Shaft rotation is easily changed by indexing the cam ring to the dowel-pin hole with the arrow indicating desired direction of rotation.

The pump consists of a housing that provides an outlet connection; a bore for support of the shaft bearing and shaft assembly; a larger bore that contains the floating pumping cartridge, made up of a front port plate, vane motor and cam ring assembly and rear port plate with a shaft end-support bearing.

Because the port plates on this pump are part of the pumping cartridge, materials were selected for maximum wear resistance. However, should it be necessary to replace these plates, it can be done by removing the end cap, and sliding the cartridge out.

This pump may be face, foot or flange-mounted in any of four positions on its mounting bracket. The suction inlet port can be assembled in many positions with regard to pressure delivery port. Price range, $203-391; delivery, 4-6 wks. **Denison Engineering Div., American Brake Shoe Co., Columbus, Ohio.**

Circle 1, inside back cover



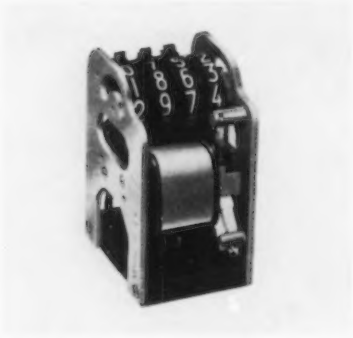
High Capacity, Low-cost Bearing

Two wheel bearings with a high capacity rating for their size have been developed for small cars similar to the European type. However, the bearings should be generally applicable, particularly since they are expected to provide savings in hub materials and allied parts such as seals and nuts. Application is expected on farm machinery, small trailers and conveyors.

The larger bearing has a bore of 1.0625 in., 1.980 in. OD, and a width of 0.560 in. The smaller bearing has a bore of 0.6875 in., 1.570 in. OD, and a width of 0.545 in. Specific load-bearing information is available directly from the company. Price and delivery figures not yet available. **Timken Roller Bearing Co., Canton 6, Ohio.**

Circle 2, inside back cover

CONTINUED ON PAGE 104

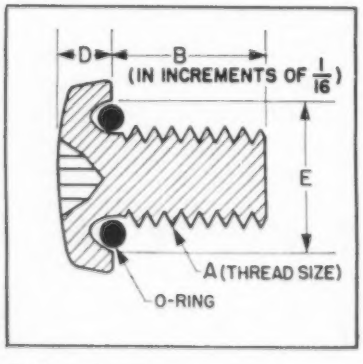


Rapid non-reset counters

are electromagnetic units with number wheels molded from a French polyamide, nylon-11 (PE, Dec. 23 '57, p. 76). The lightweight (1.1 oz) counters display white numbers $\frac{3}{32}$ in. high from 0000 to 9999. Operates on 22 to 29 v dc on pulses of 10 millisec to a max rate of 37 counts per sec. Construction is the same as that of a stepping relay. Two solenoids work in parallel to increase speed. Counters withstand shock to 10 g in two directions while maintaining accurate count. Meet military specs for shock, vibration and temperature.

Can be supplied with plug-in connection or flying leads. The 1.614-in. high x 1.142-in. counter was developed for airborne instruments and units but can be used in such varied applications as vending machines and remote-control units for industrial machines. Delivery is 6 wk. Price on East Coast is about $24 per counter. Counters are made in England and represented here by **Counting Instruments Ltd., Sheffield, Mass.**

Circle 3, inside back cover



Self-sealing screws . . .

for high-pressure sealing of panels, motor housing and equipment prevent entry of moisture, dust or combustible vapors. Supplied as one-piece, preassembled units. Design employs an O-ring completely contained in groove underneath head of screw. When screw is tightened, O-ring is compressed to form a positive seal. Standard O-rings are molded from silicone rubber. Furnished in 4/40, 6/32, 8/32, 10/32, 10/24 and $\frac{1}{4}$-20 in stainless steel. **Automatic & Precision Mfg. Co., 252 Hawthorne Ave., Yonkers, N. Y.**

Circle 4, inside back cover

High-density polyethylene . . .

withstands temperatures to 240 F without change. It does not lose its shape in contact with boiling water and will not crack, shatter or become brittle at low temperatures. Properties of heat and cold resistance gives material potential usage in applications where sterilization is required. Rigidity and high impact strength coupled with acid and alkali resistance make it suitable for pharmaceutical packaging, household utensils, machine parts and housings, utility boxes and battery cases. Embossing will give it various textures or grain. Available in width from 70 to 0.020 in. in thicknesses of 0.006 to 0.070 in., and in any color. **Bolta Products Div., General Tire & Rubber Co., Lawrence, Mass.**

Circle 5, inside back cover

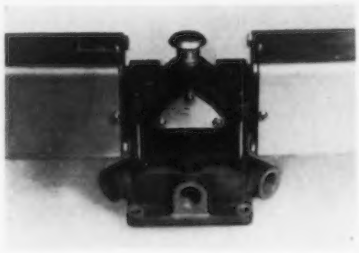
250 kc plug-in circuits . . .

use germanium transistors. For applications in timing, control and computer systems. Flip flops in three types, a squaring amplifier, one-shot, emitter followers, dc AND gates, dc OR gates, reset generator, pulse-inverting amplifier, dual pulse amplifier, pulse AND gates are available now. Circuits are totally enclosed in a metal case $\frac{7}{8}$ in. dia with a seated height of $2\frac{3}{16}$ in. Cases may contain more than one circuit, are not potted and can be opened without special tools. **Engineered Electronics Co., 506 E. First St., Santa Ana, Calif.**

Circle 6, inside back cover

Solenoid plug-in valve . . .

is a four-way, three-position unit rated at 100 psi pneumatic service, operated by 115 v ac, 60 cps. Designed with quick-disconnect features for servicing and replacement. Valve has been tested for several million operating cycles without malfunctions. Port sizes are $\frac{1}{2}$-in. NPT dry seal throughout. Valve consists of the base or manifold and the body or operating assembly. Made of die-cast aluminum, it is lightweight and corrosion-resistant. Requires no lubrication. Currently intended for pneumatic applications, design is adaptable to hydraulic use or to bulk handling of fluids by modification of present seals. **Whittaker Controls, Div. of Telecomputing Corp., 915 N. Citrus Ave., Hollywood, Calif.**



Circle 7, inside back cover

Thermal circuit breaker . . .

compensates for ambient temperature. It will carry rated current at 250 F and 115% of rating at 77 F and −60 F. The breaker is a push-pull, indicating type that withstands environmental conditions of shock, vibration, corrosion and humidity, meeting military specs. Weighs 0.2 lb, has standard life of about 10,000 cycles. Rupture capacity is 2500 amp, min, 400 cps, 115 or 200 v ac and 6000 amp, 28 v dc. **Spencer Thermostat Div., Metals & Controls Corp., Attleboro, Mass.**

Circle 8, inside back cover

Two-piece rod end . . .

is designed to insure the largest possible surface-contact area between housing and ball. Standard housing and shank material is high-tensile pearlitic malleable iron, rated 70,000 psi. Hard-chrome-plated alloy steel, and ground and hardened sintered steel balls treated with a high-pressure, dry film lubrication coating are the two basic alloys used. Ball-housing surface has a permanent dry-film lubricant coat. Body is cadmium plated. The full hexagon shape of the female rod end and the heavy throat base of the male rod end

CONTINUED ON PAGE 106

Over $1,000,000 a year

saved with OILITE Precision Parts

This kit contains intricate parts used by a score of companies who save over $1,000,000 annually by specifying Oilite*!

These companies are typical of many manufacturers of appliances, machinery, automotive accessories, power tools and other products who enjoy the substantial cost reductions made possible by Amplex Powder Metallurgy.

You, too, can have a share in these savings. Chrysler-engineered Oilite Precision Parts can save you up to 55% or more when produced in volume. What's more, you'll find Oilite powder metal parts tough and long wearing. They're available in a large variety of metals and alloys to meet required properties.

Your local Oilite Engineer will be glad to provide complete information on any application. Furthermore, he will gladly survey all the parts you now buy for possible cost reductions *at no obligation*. Look for him in the Yellow Pages of your telephone directory under "Bearings — OILITE" or write to Dept. A-3.

TYPICAL PROPERTIES OF STEEL OILITE* PRECISION PARTS

(Grades)	A	AC	AH
Fatigue Strength (Psi) 10,000,000 reversals	24,000	-----	------
Ultimate Tensile Strength (Psi)	35,000	50,000	120,000
Compressive Strength (Psi) .001" permanent set	25,000	80,000	150,000
Elongation in 1", % minimum	10	5	1
Brinell Hardness	80	140	300
Shear Strength (Psi)	27,000	35,000	100,000

* Many other materials giving different properties available.

Engineers in the principal cities in US and Canada.

A CHRYSLER OILITE PRODUCT

SINCE 1929

the most trusted name in powder metallurgy

AMPLEX DIVISION

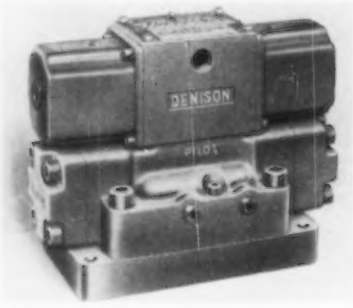
CHRYSLER CORPORATION, DETROIT 31, MICHIGAN

BEARINGS • PRECISION PARTS • METAL FILTERS • FRICTION UNITS

* REGISTERED TRADEMARK • ONLY CHRYSLER MAKES OILITE.

simplify installation. Both female and male types are available in standard bore sizes from ¼ to ¾ in. **Automation Bearing Corp., 120 Colonial Ave., Bridgeport 1.**

Circle 9, inside back cover



Solenoid, 4-way valves . . .

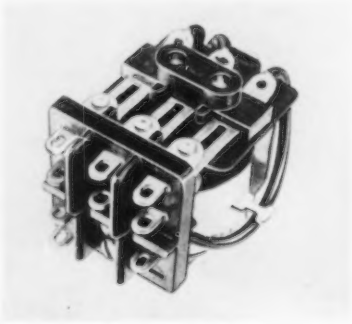
are pilot-operated, designed to provide all porting and positioning arrangements on circuits to 3000 psi. Valves are said to be shorter over-all than comparable valves. A choice of spool types and spool positioning provides all combinations needed for a wide range of applications. Capacities are 30 gpm and 5 gpm for the ¾-in. four-way and ¼-in. solenoid valves, respectively. Available singly, too. Interchangeable with comparable valves now in use. **Denison Engineering Div., American Brake Shoe Co., 1160 Dublin Rd., Columbus 16.**

Circle 10, inside back cover

Molded terminal boards . . .

offer a solid, insulated back that eliminates a separate insulating strip between screw end and ground. Thicker, higher barrier design increases creepage path by 12% over comparable terminal boards. Molded-in conductors provide positive connectors. Series can be marked right on barriers, eliminating marker strips. Molded-in inserts around mounting holes provide increased sectional strength at these points. Terminal boards are said to have greater amperage capacity. Available for immediate delivery; competitively priced. **General Products Corp., 26 Rittenhouse Pl., Ardmore, Penna.**

Circle 11, inside back cover



General-purpose relay . . .

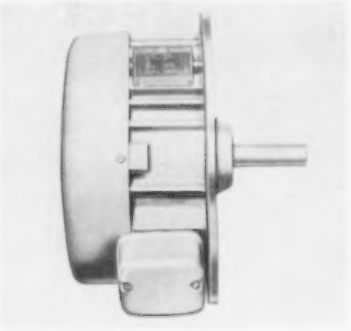
with silver or silver-cadmium-oxide contact arrangements to 3PDT are rated 5 or 10 amp resistive. The small relay, structed using UL-specifications, is available in open and plug-in models. The latter is offered in clear or tinted polystyrene housings. Coils are rated for all standard ac and dc voltages and 2500, 5000 and 10000 ohm for plate circuit use. Insulators are molded Bakelite. **Line Electric Co., 271 S. Sixth St., Newark 3, N. J.**

Circle 12, inside back cover

Speed control . . .

cuts power off when speed of rotating devices exceeds a preselected value. Input signal to the unit is obtained from an ac tachometer generator or magnetic pickoff coil. Detector may also be used with turbine flow sensors to provide an alarm or cutoff at preselected flow rates. Response time within 10 millisec is achieved through transistor switching for output current control. Operates on 28 v dc and provides a 28-v output signal capable of operating external solenoid valves or relays when input signal reaches trip frequency. Trip point accuracy is within 1%. **Waugh Engineering Co., 7842 Burnet Ave., Van Nuys, Calif.**

Circle 13, inside back cover



Shorter pancake motor . . .

achieves its shorter length without reduction in motor performance through formed end coils and a combination cast-iron housing and bearing bracket. Motor is flange-type of conventional radial, air-gap design. Available in ratings from 1 to 15 hp at 1800, 1200 and 900 rpm. Motor can be mounted vertically or horizontally. Has factory-lubricated bearings. For normal operating conditions, it is built in an open, drip-proof enclosure. Designed for machine tools, roof-ventilating fans and other space-cramped applications. **Louis Allis Co., Dept. P, 427 E. Stewart St., Milwaukee 1.**

Circle 14, inside back cover

Thermoplastic sealant . . .

is said to have excellent adhesive qualities with ceramics, Bakelite, paper, metals and other materials. Sealing compound have high melting point and can replace epoxies in some sealing applications. Pouring temperature of eggshell-white compound is 400 to 440 F. It is applied by melting and pouring into place with complete solidification upon cooling. Softening occurs from 332 to 337 F. There is no cold flow at 270 F. **Biwax Corp., 3445 Howard St., Skokie, Ill.**

Circle 15, inside back cover

Planetary gearmotors . . .

are integrally mounted, single-worm units combining low speeds of double reduction units with light weight. For example, a ½-hp unit at 14.5 rpm delivers 1260 in.-lb torque output and measures 14⅛ in. long x 13⅛ in. wide. A comparable double-worm unit is rated for 1216 in.-lb output. Frame is a heat-treated aluminum alloy; motor insulation is Mylar-silicone. Motor and worm shaft are joined by a tang coupling for easy assembly and disassembly. Planet cage and output shaft are a single piece, planets run on needle bearings.

CONTINUED ON PAGE 108

Reclaiming old drawings is just one of the jobs you can do with Kodagraph Autopositive Paper

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AS YOU CAN SEE, the drawing shown above is badly beaten up. Its line detail is weak, its background soiled from old age and considerable handling. And the blueprints and direct-process prints it produces are likely to be illegible.

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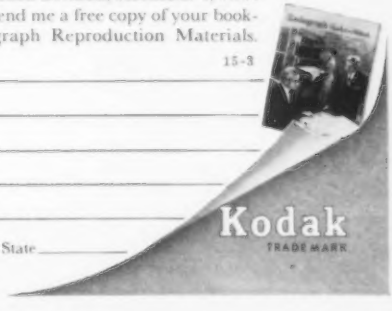
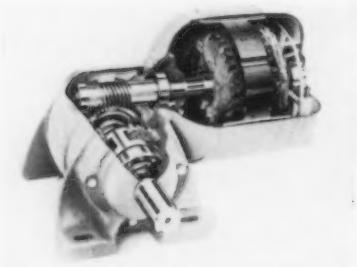
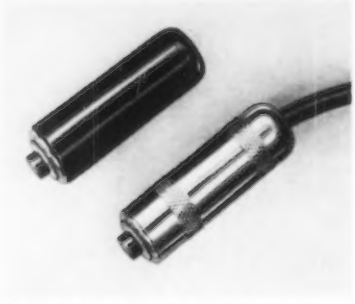




Available in foot or ring-mounted frames, ¼ through 1 hp, 38 through 3 rpm. **Electra Motors, Inc., 1110 Lemon St., Anaheim, Calif.**

Circle 16, inside back cover



Remote-control switch . . .

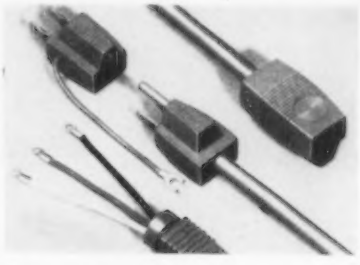
consists of small non-locking red or black pushbuttons enclosed in a nickel-plated or black phenolic housing. The cord switch is rated at ¼ amp, noninductive load, 30 w ac max. **Switchcraft, Inc., 1328 N. Halstead St., Chicago 22.**

Circle 17, inside back cover

Load control relay . . .

for use with three-phase induction motors. Load change sensitivity in the range of 30% or less of rated load is equal to or exceeds sensitivity of current-sensitive devices at heavier motor loadings. Unit responds to changes in input power, providing advantages that are most marked when motor is lightly loaded. Can be used for such applications as end of spark-out on grinders, determining when a machine process has started, loss of prime on pumps, certain fans and blowers. **Machinery Electrification, Inc., 56 Hudson St., Northboro, Mass.**

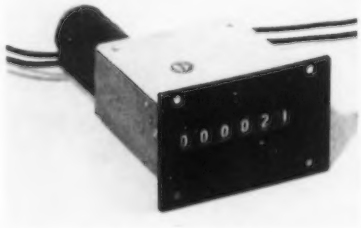
Circle 18, inside back cover



Three-wire cordsets . . .

for appliances that must be electrically grounded under UL and NEC rules are style-matched. Plugs and connectors are vinyl plastic, molded in one piece, bonded with cord insulation, and can carry manufacturer's trademark impressed in the material. For locations with two-wire outlets, an adapter permits use of the three-wire attachment caps. Plastic is resistant to oil and chemicals. A special vinyl is available for flexibility at low temperatures. **Miller Electric Co., Pawtucket, R. I.**

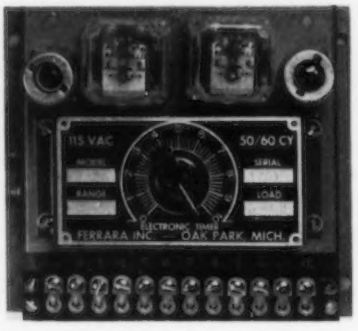
Circle 19, inside back cover



High-speed reset counters . . .

are rated at 3000 counts per min, tested at 6000 counts per min for extended periods. Life is said to exceed 200 million counts. Coil operates on dc; external rectifier required for ac power. Coils are designed for continuous duty. Instant reset is a feature of both the electrical and manual reset types. Dimensions: 1.7 x 2.1 in. for four-figure counter and approximately 1.7 x 2.8 in. for six figures. **Veeder-Root, Inc., Hartford 2, Conn.**

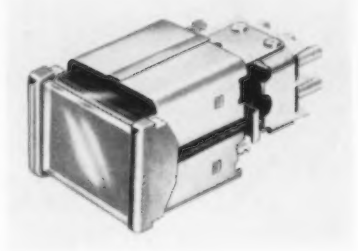
Circle 20, inside back cover



Electronic timer . . .

can be used for single or repeat cycle, interval or delayed-action timing. It has a regulated power supply, plug-in relays, 5-amp isolated load contacts. Available for panel mounting or enclosed in NEMA 1A or 12 box in 25-millisec-to-50-sec timing ranges. **Ferrara, Inc., 8106 W. Nine Mile Rd., Oak Park 37, Mich.**

Circle 21, inside back cover



Lighted pushbutton . . .

for modular mounting on control panels combines nameplate, pilot light and switching unit. Can be stacked or individually mounted. Meets a wide range of operating and indicating conditions through combinations of lamp circuits, switching circuits, lamp colors, pushbutton colors and nameplate. Basic switch unit has mechanical and electrical life of 50,000 operations with current rating of 5 amp at 125 to 250 v ac; on 30 v dc, 4 amp resistive and 2.5 amp inductive. **Electro-Snap Switch and Mfg. Co., 4220 W. Lake St., Chicago 24.**

Circle 22, inside back cover

Self-locking anchor nuts . . .

with a deep counterbore are designed to speed production and reduce weight where members of varying thicknesses must be joined. The design saves several times actual weight of the nut by eliminating multiple shims that would otherwise be required. Configurations available include a

CONTINUED ON PAGE 110

You Get More For Your Metals Dollar With Bridgeport Brass and Copper

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If you use brass, copper or bronze strip where fine surface is a "must," you'll benefit from the beautiful, lustrous finish you get with Bridgeport Strip. Now coming from our new Sendzimir Rolling Mills, this new kind of strip reduces polishing time, improves plating and adds to the quality of your products.

In addition to its exceptionally fine surface, Bridgeport "Deep Luster" Brass Strip has remarkable uniformity of gauge and mechanical properties from edge to edge and from end to end. It's available in long-length coils for more economical production.

If you're not using brass strip now, it will pay you to consider its many important advantages over other materials. And with Bridgeport Strip you get the extra quality that Sendzimir rolling builds into it.

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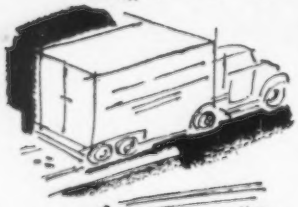

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INSTALLATIONS ARE CHECKED—At Cambridge, orders aren't filled and forgotten. Our own sales engineers follow up your order to make sure our product is giving you the best possible service.

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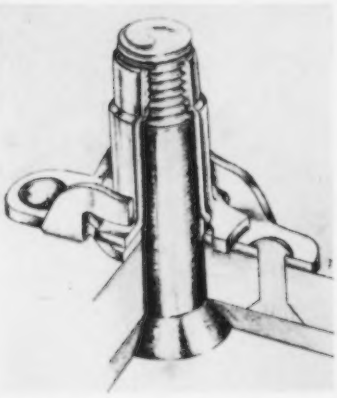
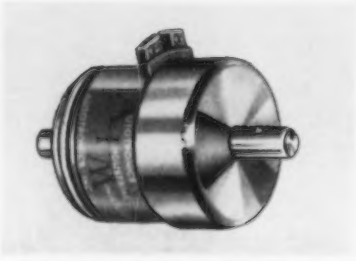


two-lug anchor nut, one-lug anchor nut, and gang-channel assembly. For service at temperatures to 550 F. One and two-lug anchor nuts are offered in thread sizes 10-32, ¼-28 and ⅜-24. **Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N. J.**

Circle 23, inside back cover



Electromagnetic clutches . . .

are self-contained units with clutching torque of 40 in.-oz. When energized, output and input shafts are coupled together; de-energized, both shafts are free running. Operate on standard voltages of 24 to 28 v dc. For servo or face mounting. Applicable to tape-recording equipment, calculating machines and numerous automatic controls. **Autotronics, Inc., Rt. 1, Box 812, Dept. 12, Florissant, Mo.**

Circle 24, inside back cover

Miniature clutches and brakes . . .

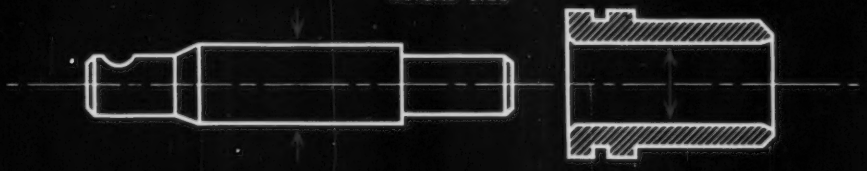
of 0.59 in. dia are available in a number of configurations and for fail-safe or reverse-energization applications. A typical clutch will reach max torque in less than 2.5 millisec, using a 1.6-w, 25-v coil. A non-rotating coil eliminates drag and objectionable limitations of slip-rings. Min torque of standard clutches and brakes is 4 in.-oz free drag is less than 0.06 in.-oz. Class 5 instrument bearings are used. Rotor design eliminates radial or axial displacement when engaging or disengaging and gives zero backlash when engaged. Mounts with

(Continued on page 114)

Coors CERAMICS

HIGH PRECISION TOLERANCES

ACTUAL SIZE



SHAFT		BUSHING	
Diameter	±0.000015	Diameter	±0.000050
Taper	0.000010	Taper	0.000010
Camber	0.000010	Camber	0.000010
Out-of-Roundness	0.000010	Out-of-Roundness	0.000010

BENDIX AVIATION CORPORATION SHAFT AND BUSHING ASSEMBLY

VERY CLOSE TOLERANCES AND CLEARANCES ON ASSEMBLY PROVIDE FRICTION FREE ACTION

Coors Alumina Ceramic is used in production quantities by the Bendix Aviation Corporation for a shaft and bushing assembly that has tolerances as close as ±0.000015. From one bushing to another, Coors holds the diameter to ±0.000050. Between one shaft and another, Coors holds the diameter to ±0.000015. On both bushings and shafts, taper, camber and roundness of individual parts are held to 0.000010 total.

Extremely close, match-fit sets of this assembly are made by selective fitting. Finishing within a few millionths is required to provide proper fits—exact clearance must be withheld.

These very close tolerances and clearances provide friction free action between the shaft and bushing. This, combined with the hardness and chemical inertness of the alumina ceramic, gives the assemblies long, trouble free service.

Guaranteed precision on a production basis permits the engineer to use Coors ceramics in applications where the physical properties of metals and plastics are unacceptable. Tolerances and finishes which can be obtained by Coors are:

Diametrical.....within 0.000030" total.
Taper.....0.000010" per inch of length*.
Camber.....0.000010" per inch of length*.
Out-of-roundness.....0.000010".
Surface flatness — less than 1 light band.
Equivalent surface finish —
3 to 4 r.m.s. microinch.

*(in lengths up to 3 inches)

For a complete description of physical properties of Coors High Alumina Ceramics, write for Bulletin 1055A.

COORS PORCELAIN COMPANY

Manufacturers of High Strength Alumina Ceramics
GOLDEN, COLORADO

COORS PORCELAIN CO., 682 9th St., Golden, Colo.
Please send me detailed Bulletin 1055A on Coors High Strength Alumina Ceramics and Coors manufacturing facilities.

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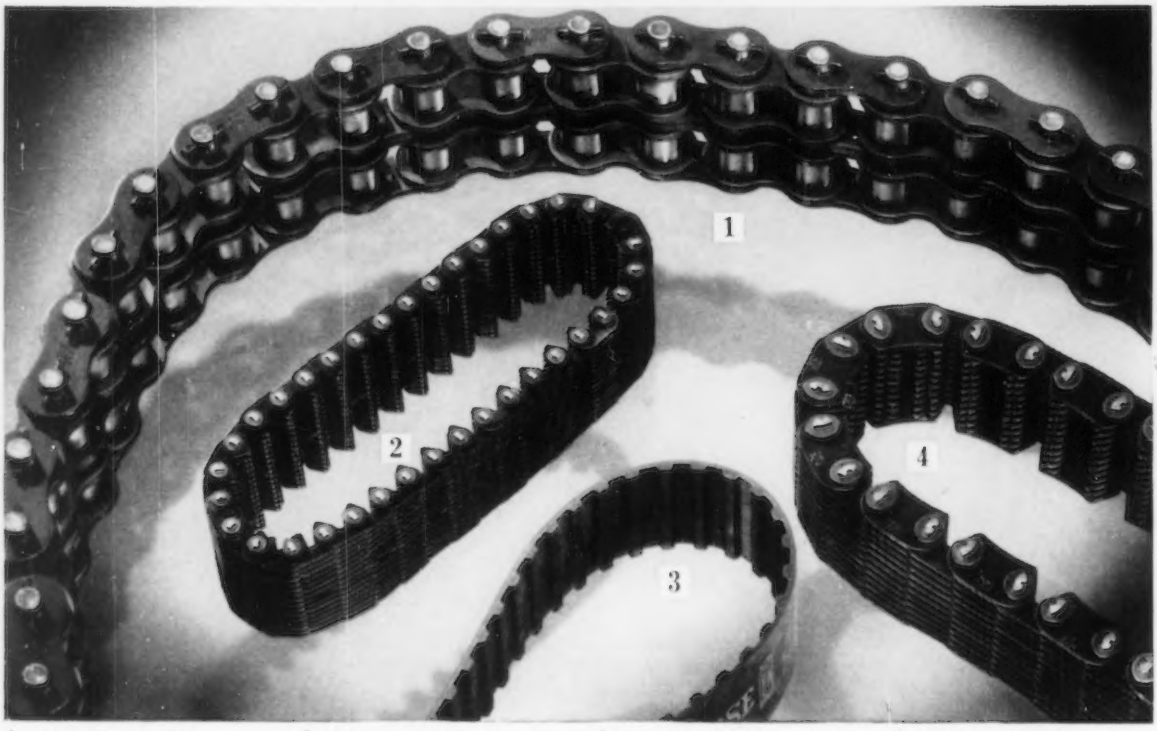

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3. "TIMING" BELT . . . for light weight, lubrication-free operation. Positive, efficient from 1/100 HP to 1,000 HP; 0 to 16,000 FPM. Slip- and stretch-proof for life of drive.

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Morse also makes a complete line of power-transmission products, including:

Basic Drives: Roller Chain, Silent Chain, Hy-Vo® Drives, and "Timing"® Belt.

Chain: High-Endurance (H-E), 8-series (Super Strength), Double-Pitch, Conveyor, Implement, and Attachment; AL, BL, Cable Chain, and Rollerless Lift Chain; Industrial Standard and 3/16" Silent Chain.

Stock Sprockets: Plain Bore, Finished Bore, Taper-Lock—also made to order.

"Timing" Belt Sprockets: Plain Bore, Taper-Lock, Q.D.—also made to order.

Couplings: Flexible Roller Chain Couplings, Flexible Silent Chain Couplings, Morflex Couplings, Morflex Radial Couplings, and Marine Couplings.

Driveshafts: Morflex and Radial Driveshafts.

Clutches: Cam (Over-Running, Back-Stopping, Indexing); Pullmore; Over-Center; Centrifugal.

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Speed Reducers: Eberhardt-Denver "RW" poweRgear® Reducers; Gear Motors; "L" Worm Gear Reducers; "VX" and "DVX" Conveyor Drives; Miter Boxes; Helical Reducers.

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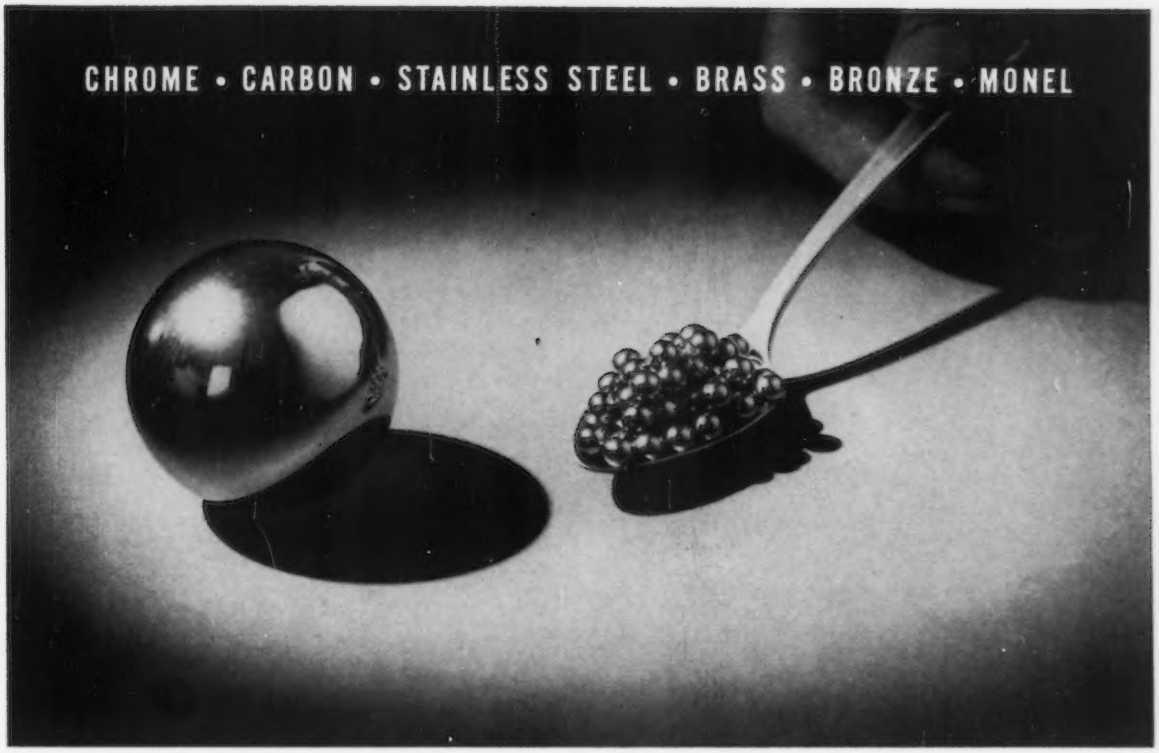

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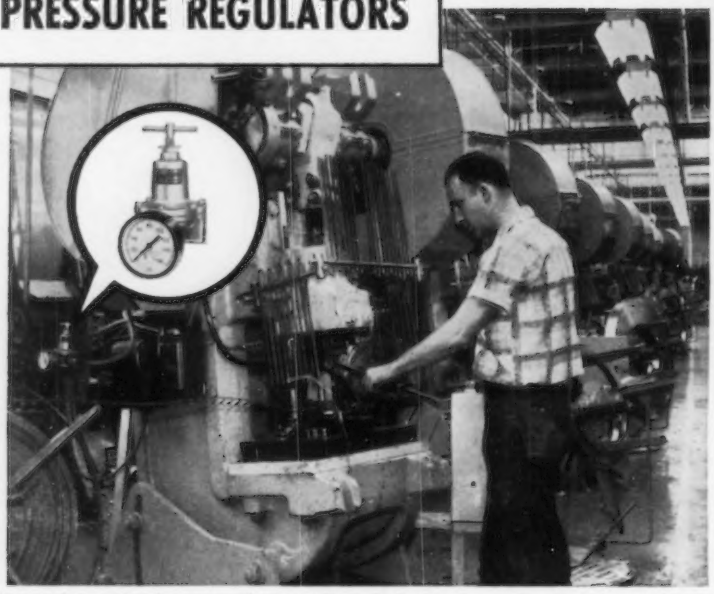
FACTS about Norgren PRESSURE REGULATORS



Norgren Pressure Regulator on punch press at Shwayder Brothers, Inc., maker of Samsonite Luggage.

Reduce Air Costs... Cut Maintenance Costs

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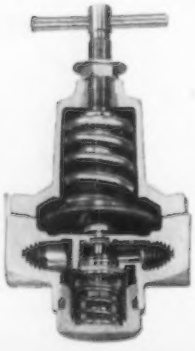

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standard ½-in. dia servo mount, on either or both ends, with concentric output and input shafts. **Magtrol, Inc., 240 Seneca St., Buffalo 5, N. Y.**

Circle 25, inside back cover

Miniature magnetic brakes . . .

clutches and clutch-brakes are available in 32 models in frames sizes 8, 11 and 18. All feature direct and reverse action. Hard clutch-coupling faces result in 5-millisec engagement time. Standard operation is on 24 to 28 v, but a complete range of operating voltage is available. Temperature range is from –65 through 350 F. **FAE Instrument Corp., 42-61 Hunter St., Long Island City 1, N. Y.**

Circle 26, inside back cover

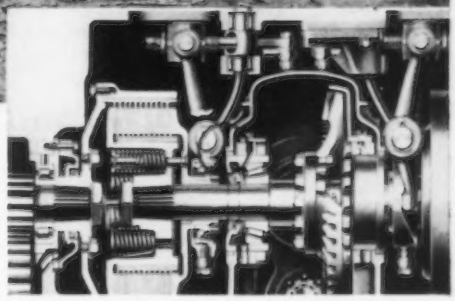
Explosionproof timer . . .

for hazardous areas can be reset. Has a cycle-progress pointer and is available in time ranges from 10 sec to 10 hr in 115-v

(Continued on page 118)

Dust Flies Fast and Furious

...when the TRAXCAVATORS* go into action!



CUTAWAY of a Caterpillar No. 955 Traxcavator to show one of the spots protected by seals of American Felt.

But vital innards are kept grit-free and oil-tight with seals of AMERICAN FELT

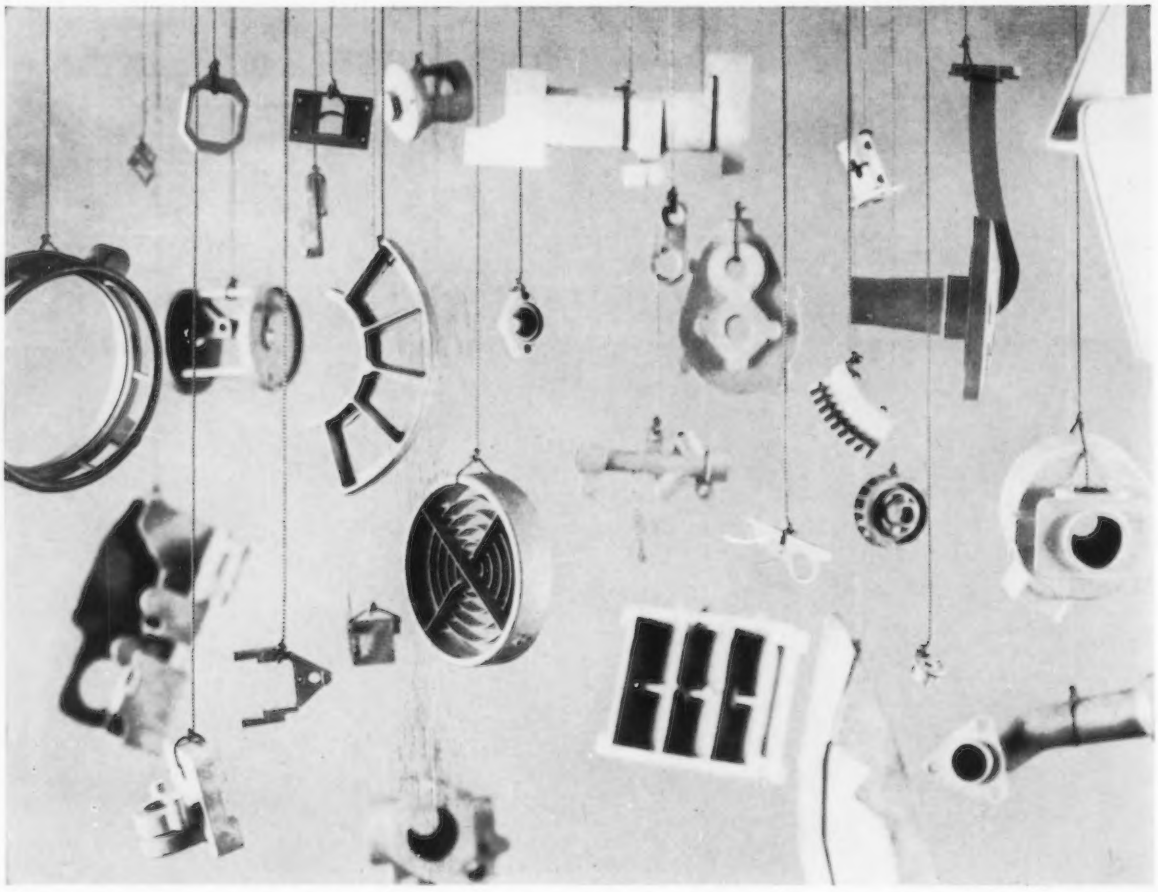
The Traxcavator, made by Caterpillar Tractor Co., is called on to handle some mighty tough jobs. Logging, grading, loading gravel and dirt are just a few. Under these conditions even the best-made engines and machines need their vitals protected against grit, dust, water and mud, and at the same time have the oils and greases kept grit-free and sealed in. To do this dual job of keeping out dust and grit and keeping in oil and grease, Caterpillar Tractor Co., Peoria, Illinois uses seals of American Felt . . . in their D4 Tractor, No. 955 Traxcavator shown and other pieces of equipment . . . to insure reliable performance and long life.

American makes various types of felt for sealing purposes, and supplies it as desired, including the very important laminated synthetic rubber and felt OILFOIL seal, cut to size. For information, write for Data Sheet No. 11, "Felt Seals, Their Design and Application."

*Caterpillar, Cat and Traxcavator are Registered Trademarks of Caterpillar Tractor Co.

American Felt Company
TRADE MARK

General Offices
Engineering and Research Laboratories
78 Glenville Road • Glenville, Conn.



This assortment of castings represents about half the number of new parts that go into production at Arwood's five plants in a typical week.

Could Investment Casting make your new part cheaper to produce?

. . . a prompt, candid answer is yours for the asking

Upon receipt of a drawing or sample of your part, Arwood will give you a prompt, honest appraisal, spelling out exactly what we propose to furnish. We will also suggest minor design changes that may save you money without affecting the part's performance.

Arwood can handle the complete job, from design and tooling through to finish machining, in any castable metal or alloy. Arwood assumes complete responsibility . . . your procurement problems are at an end.

Arwood's five fully-equipped production plants and well-staffed tool rooms are geared to give fast service. Each job is individually scheduled to assure you of delivery of finished castings in the shortest time possible.

Large and small companies come to Arwood for quotations at the rate of fifty a day . . . without obligation. Why not let us help *you* evaluate the potential savings you may realize by making your part an Arwood investment casting?

Write today to reserve your free copy of the new 48-page Arwood Manual of Investment Casting, soon to come off the press. Provides all the information you need to evaluate the technique and use it to help solve your design problems.

arwood

ARWOOD PRECISION CASTING CORP.
325 West 44th Street, New York 36, New York

A complete service from design through tooling, production and finish machining. Sixty-two engineering consultants from coast to coast.

PLANTS IN BROOKLYN, N. Y.; GROTON, CONN.; TILTON, N. H.; LOS ANGELES & N. HOLLYWOOD, CALIF.

NEW...

POWER-PACKED CHAMPS OF THE AIR-COOLED ENGINE FIELD

by HERCULES

HERCULES C2-90D
Design by Lycoming
35 HP; 274 pounds, dry

HERCULES CV4-180
Design by Lycoming
70 HP; 463 pounds, dry

No other industrial air-cooled engines pack the horsepower/pound of these two- and four-cylinder models. Modern design gives them 40-90% more HP per cubic inch displacement. Add to this high usable power, the economy of these engines . . . up to ⅓ in fuel savings over competitive engines . . . and you've got an unbeatable combination for your equipment power or power-unit applications.

The Hercules industrial air-cooled engines of Lycoming design have the dependability and endurance for which the Lycoming name is famous in aircraft engines. Crankshaft design is oversize and all bearings are of the replaceable type. With overhead valves, "top-overhaul" is fast and simple on these Hercules units; in fact, complete engine rebuild can be accomplished without removing the engine from its mountings.

Lubrication is by force-feed system with the oil fed from the crankcase to the engine's moving parts by gear-type pump through a pressure relief valve.

Available as engines or complete power-units, with accessory equipment to match service conditions, these engines have been refined by Hercules and are backed by Hercules reputation for quality, stamina and engineering excellence. Prompt service is available through Hercules world-wide distributor organization.

For further information, write Hercules Motors Corp., Dept. 100, Canton 2, Ohio. Other Hercules engines from 5 to 475 HP.

HERCULES

HERCULES MOTORS CORPORATION
Canton, Ohio

A TALENT FOR INVENTION: Leroy® Lettering Equipment—a K & E development—insures perfect neatness and uniformity, yet it is simple to operate and requires no special skill or training. One man can start a job and another finish it without any variation in lettering.

This K & E equipment comprises three basic, precision engineered parts: Leroy template, Leroy pen and Leroy scriber. Capitals, lower case, numerals, vertical or forward slanting letters can be drawn from a *single* template—an *exclusive* K & E feature. You can buy templates, pens, and scribers separately or in convenient sets.

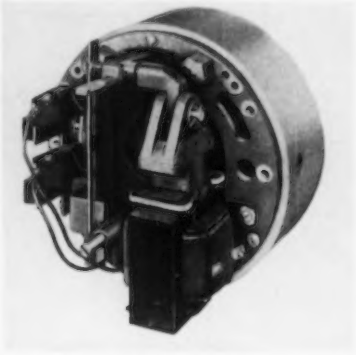
Leroy templates offer a variety of alphabets, sizes and graphic symbols. Electrical, mathematical, mapping, geological and other symbol templates are available. Templates, with words or phrases that are frequently repeated, as well as templates with your own symbols, trade marks or designs, can be made to your order.

To save time and money in your drafting room specify K & E Leroy® Lettering Equipment. For other drafting or engineering equipment and materials also look to Keuffel & Esser Co.—your "Partners in Creating"—who have served engineering for 90 years.

KEUFFEL & ESSER CO. New York, Hoboken, N.J., Detroit, Chicago, St. Louis, Dallas, San Francisco, Los Angeles, Seattle, Montreal.

and 230-v models. Contacts are rated 10 amp. A max of four load circuits are available for external functions. Cone-shaped cover may be removed for wiring and inspections. Two ¾-in. openings are provided for conduit connection. Designed for flush mounting. Over-all dimensions are 5¾ x 5¾ x 8¼ in. **Eagle Signal Corp., Moline, Ill.**

Circle 27, inside back cover



Shunt-wound dc brake . . .

offers torque ratings of 10 ft-lb through 105 ft-lb, with standard and dust-tight waterproof enclosures. Brake can be floor or motor-mounted. Model has single-solenoid construction, single-point adjustment for lining wear, visual indication of lining wear and manual release and automatic reset. **Stearns Electric Corp., 120 N. Broadway, Milwaukee 2.**

Circle 28, inside back cover

Dc voltage regulators . . .

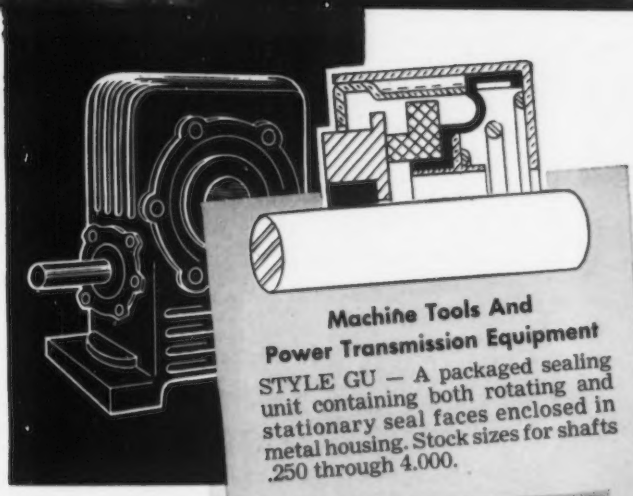
are transistor-equipped and are designed to power individual pieces of equipment. This model handles from 25 to 30 v dc and supplies 24 v dc. Regulation is ± 0.5% for line variations; load variations are regulated from 500 milliamp to 2 amp. Response time is 5 millisec for no-load to full-load variations. Max transient overshoot caused by load changes is held to 1 v. Size is 2½ x 3½ x 1⅝ in.; weight is 11.5 oz. Another model, rated at 4 amp, is also available. All units operate in ambient temperatures from –68 to 159.8 F. **Modern Industries, Inc., 2601 Colorado Ave., Santa Monica, Calif.**

Circle 29, inside back cover

Studs and inserts . . .

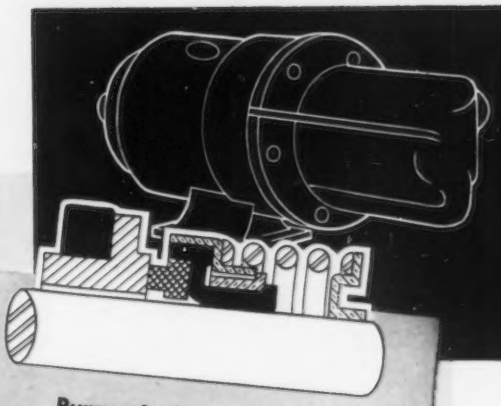
seal hydraulic component and system parts against pressures to 3000 psi in hydraulic, pneumatic and other pressurized fluid systems. Stud and insert each have a collar at a specified distance above top of threads. Below this collar is an annular recess for the packing ring. When the fastener is

(Continued on page 122)



Machine Tools And Power Transmission Equipment

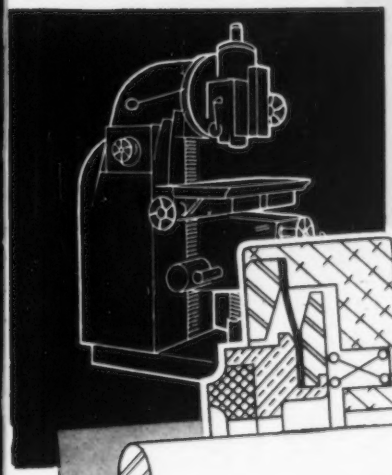
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

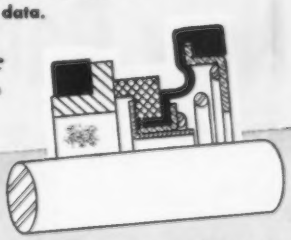
A Complete Line
GITS SHAFT SEALS
For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

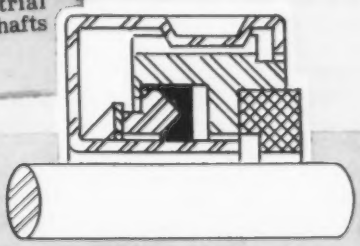
1838-B South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



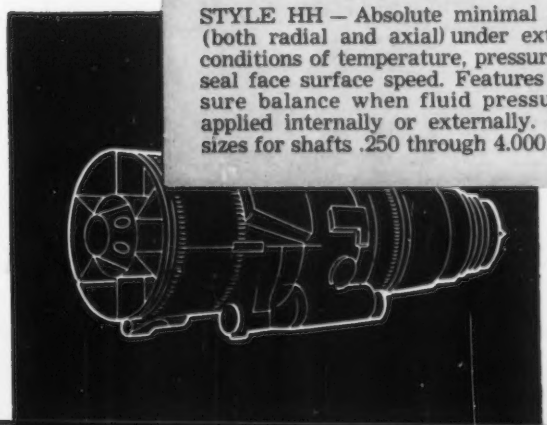
Household Appliances

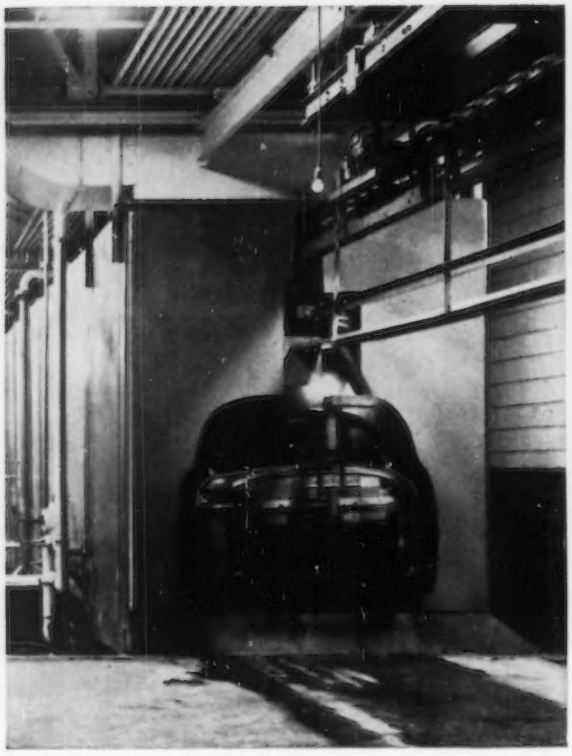
STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



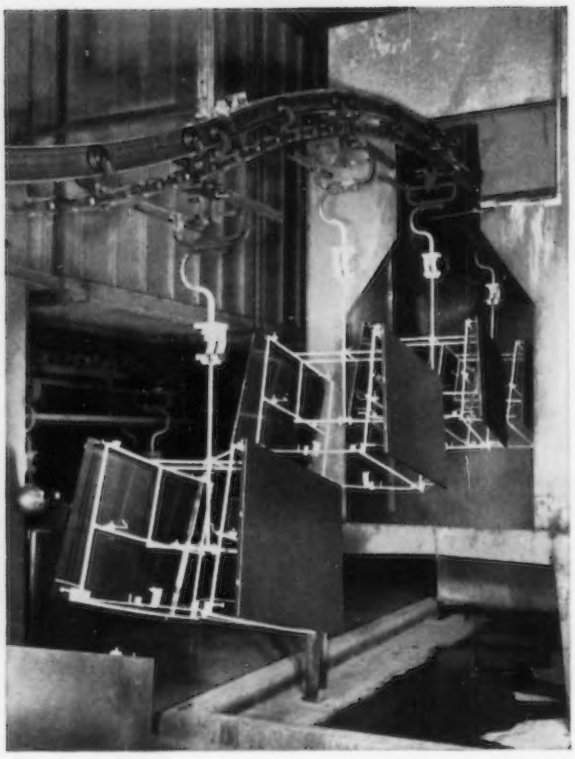
Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.





BODY LINES save up to 10 to 12¢ per body



APPLIANCE LINES save up to 4 to 5¢ per cabinet

New Parker COLD BONDERITE SYSTEM slashes steam costs!

Want to save up to 70% of heating costs on your phosphate coating line? Put in the amazing Cold Bonderite System, newly developed for low temperature operation.

It includes a new cold alkaline cleaner, specially developed to remove grease and soil through an effective temperature range of 60° to 120°. A new Spra Bonderite works in conjunction with the cold cleaner, producing excellent coatings at low temperatures. B.T.U. requirements are drastically reduced, with no sacrifice in quality.

Chemical costs of the new Cold Bonderite System just about match conventional cleaner and phosphating materials. Operation and control are simple as can be.

New Cold Bonderite System is at work right now—has been for months—in several famous production plants. It's a *proven* money-saver!

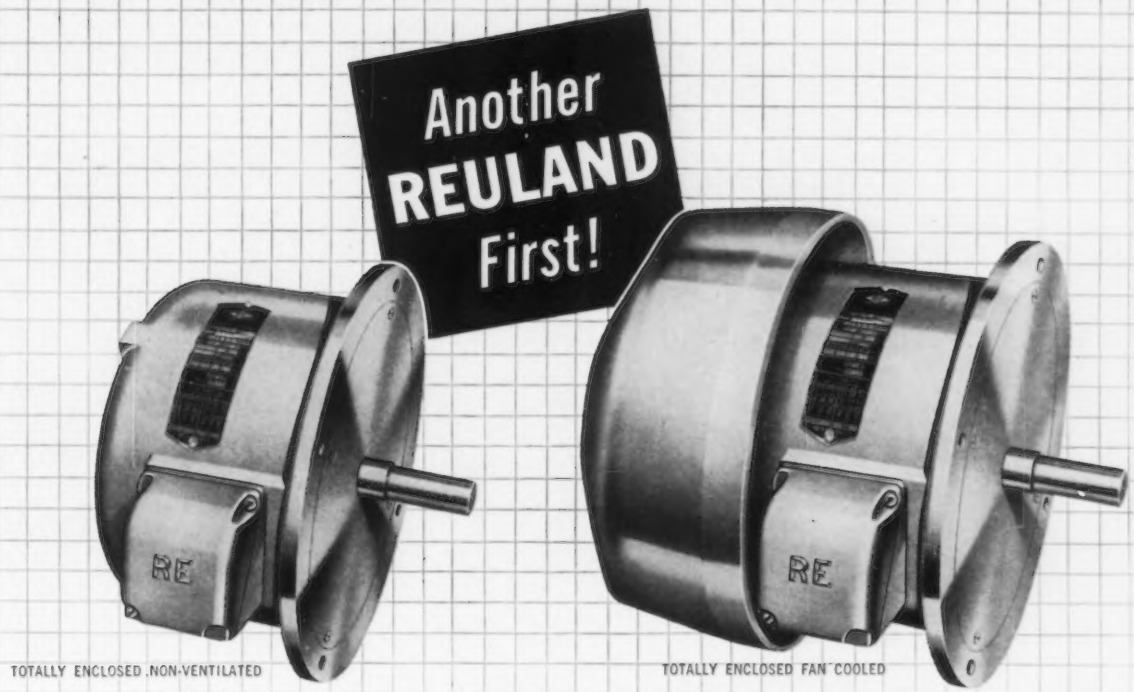
Find out how much Cold Bonderite System will cut *your* phosphate line heat costs. Write or call for complete information.

Since 1914—leader in the field

PARKER RUST PROOF COMPANY
2179 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

*Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.



TOTALLY ENCLOSED NON-VENTILATED

TOTALLY ENCLOSED FAN COOLED

MOST BEAUTIFUL MOTORS IN ALL THE WORLD...

NEW REULAND PRECISION MOTORS FOR MACHINE TOOLS

Designed especially for machine tool manufacturers

Reuland precision motors were developed only after giving a lot of careful thought to the problems of the machine tool industry. They are not just another line of motors that can be "made to fit," but rather, a complete new type especially made for machine tool manufacturers.

They are available in T.E.N.V. and T.E.F.C. types. Small, compact and featuring the very latest in lightweight materials.

For good looks and precision operating characteristics, there is nothing on the market to equal these jewel-like units.

Precision balance

Reuland motors are built to precise specifications like a fine tool. Each unit is dynamically balanced at the factory to assure vibrationless operation.

Heavy-duty ball bearings, located at each side of the rotor, assist in maintaining this characteristic which is so vital to precise work. Exact tolerances are likewise maintained throughout final assembly.

Low inertia rotor

The radial air gap design of these motors permits the use of a lighter weight, low inertia rotor. This light weight, low inertia feature assures smooth starts and quick stops.

This rotor is also of a special narrow design which has shortened up the overall length of the motor to give a thinner, "wafer" effect.

Smooth-finished castings —pleasing lines

The smoothly finished surfaces of Reuland machine tool motors are a match for the most expensive tool. All castings are specially processed for smoothness and are given a baked enamel finish.

This fine-quality finish, together with the motors' naturally pleasing lines, assure a harmonious blend with the lines of every machine tool on which they are mounted. (When desired, the motor's frame size can even be varied to fit an *exact* contour of the machine.)

Other Reuland firsts!

1. Motor with internal fluid coupling
2. Spline-coupled hydraulic pump motor
3. Foot-mounted disc type magnetic brake with self-contained bearings and shaft
4. "Through-Shaft" magnetic disc brakes
5. Slip Ring motors in small #66 frames
6. All-aluminum motor frames
7. "Xpandable" motor design

Use these other free Reuland Services

RE®

Special-Motor Library

Don't ever pay for special-motor development costs before you check this free library. Contains valuable data on hundreds of unique, specially designed motors. Send for free "how to use" booklet.

Standard Motor Catalog

Contains engineering information on Reuland's complete line of standard motors and motoreducers. Sent free on request.

REULAND MOTORS

REULAND ELECTRIC COMPANY
Western Division: Alhambra, California
Eastern Division: Howell, Michigan
Distributors in all principal cities

Advanced aluminum rotor casting process prevents air bubbles and shrinkage that cause stress and trouble!

For over a third of a century Baldor has pioneered many new ways to build electric motors better . . . for less money. Baldor's aluminum-cast rotor in the new NEMA frames is a good example.

This careful, precision method of casting produces a rugged, stress-free rotor without air bubbles and shrinkage cavities that can cause broken bars . . . loss of power . . . and motor damage! New design refinements have also improved torque characteristics while lowering the noise level.

Engineering extras like this (without extra cost) are your guarantee that you can specify Baldor Streamcooled Motors with complete confidence.

FOR MORE INFORMATION ON THE COMPLETE LINE OF BALDOR MOTORS, WRITE . . .

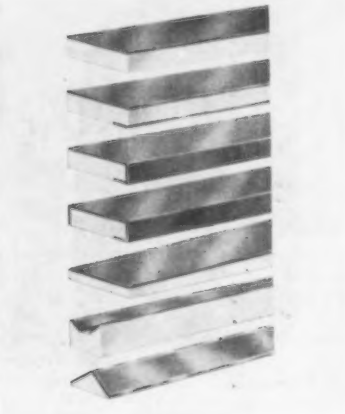
BALDOR
ELECTRIC COMPANY
4351 Duncan Avenue • St. Louis 10, Missouri

Over 500 Authorized Sales & Service Distributors In U. S. A.

District Offices: Atlanta • Chicago • Cleveland • Dallas • Dayton • Des Moines • Detroit • Litchfield, Conn. Los Angeles • Milwaukee • Minneapolis • New Orleans • New York • Kansas City, Mo. Oakland • Philadelphia • Portland, Ore. • Syracuse.

screwed into a counterbored threaded hole, the packing ring sits between the bottom of the collar and the bottom of the counterbore, stopping any leakage. Fasteners are locked by a second collar, above the first, that is radially serrated around the outer edge, and a lock ring, also radially serrated, that is placed over the fastener. **Rosan, Inc., 2901 West Coast Highway, Newport Beach, Calif.**

Circle 30, inside back cover



Hardened standard ways . . .

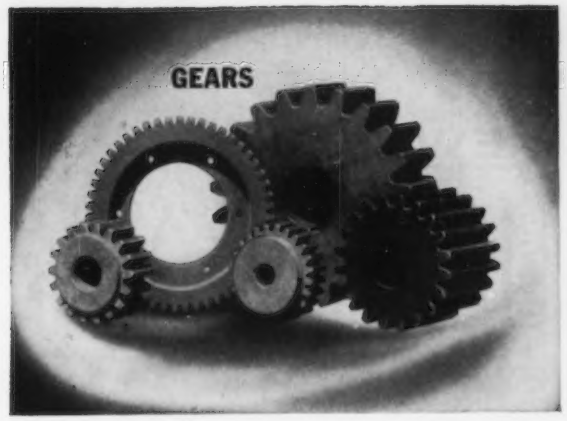
in seven different cross-sections and more than 60 sizes are available for 10-to-30-day delivery. 24-hr delivery is offered on standard aluminum-bronze slides. Ways are produced by bonding special-analysis tool steel to a soft, tough, easily machinable base. Tool steel hardness is 65-66 RC, through full depth. **Ohio Knife Co., Dept. B-75, Cincinnati 23.**

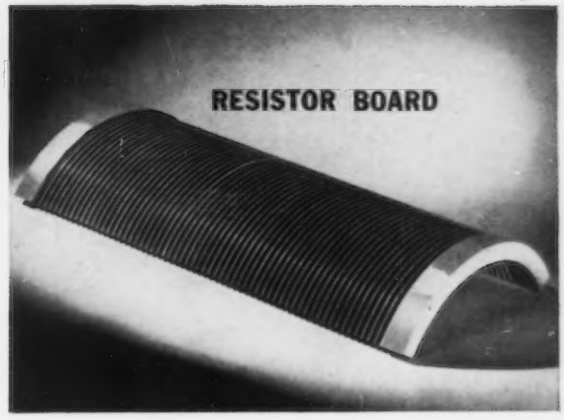
Circle 31, inside back cover

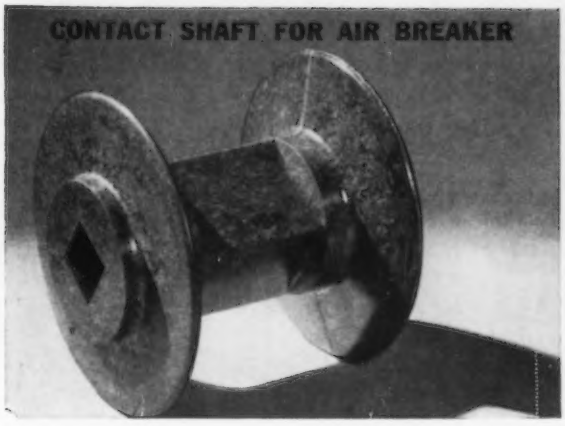
Displacement transducer . . .

is 2½ in. long and has output of 0.25 mv per 0.001 in. displacement per volt input at 60 cps. Range of linear motion is ± 0.250 in. Ceramic bobbin of the ⅜-in. dia coil is wound with Teflon-insulated wire and encased in a stainless steel shell. Coil

(Continued on page 126)







Low-cost and with controlled electrical properties. CDF Celoron Molded Plastics are designed for use in electrical and mechanical applications requiring high impact strength with good mechanical and electrical properties.

Close tolerances and high finish with phenolic resin-impregnated

CDF CELORON® MOLDED PLASTICS

CDF Celoron Molded Plastics give you all the advantages of low-cost form molding of electrical and mechanical parts. You can even add strength selectively to any section of the item.

Through lower unit costs, CDF Celoron Molded Plastics offer you longer life per dollar invested. Resist water, oil, grease, and many other corrosive solutions and atmospheres. In gears, they operate without continuous lubrication at temperatures of up to 150°F.—300°F. in oil. CDF Celoron Molded Plastics are also sound-absorbent, shock-resistant, and abrasion-resistant.

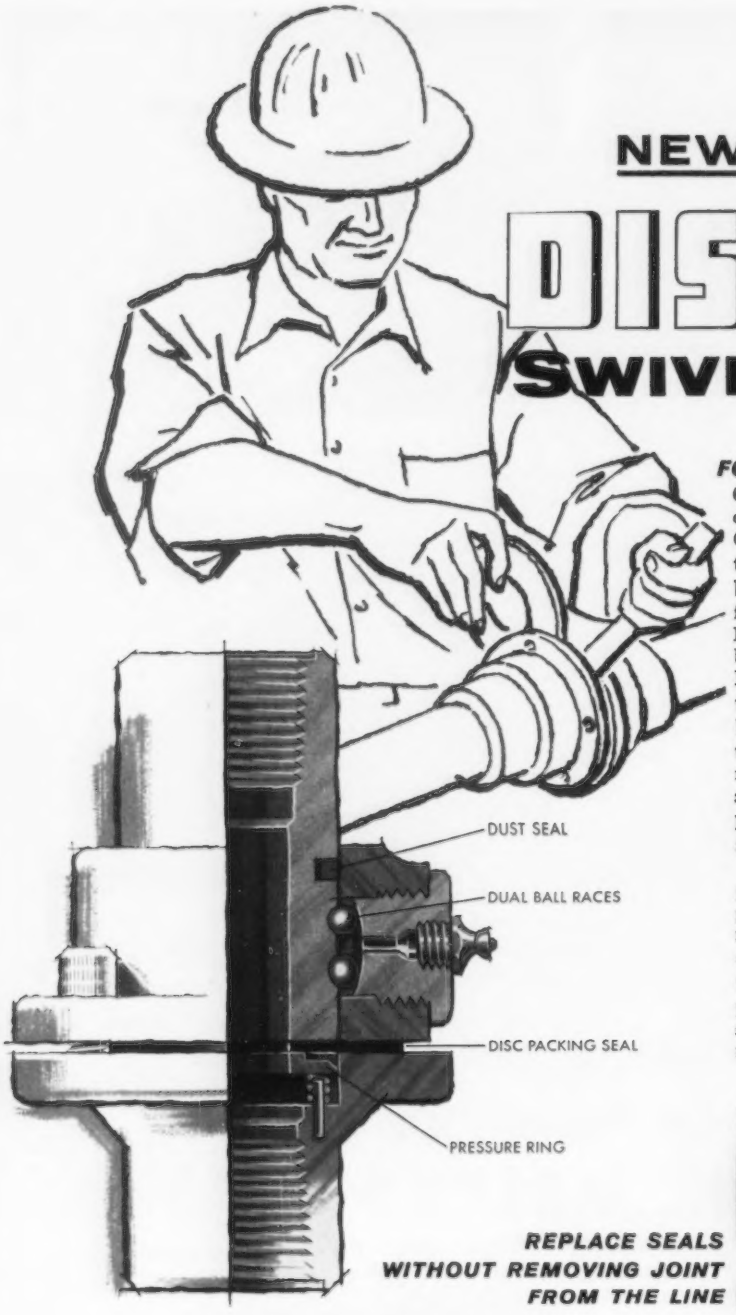
You can save machining time through CDF's custom molding and complete fabrication facilities. You'll also save costs through CDF's mass production of Celoron parts.

See your CDF sales engineer today. He'll show you how CDF Celoron Molded Plastics, plus complete custom molding and fabrication, can save you production time and costs.

CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Budd COMPANY, NEWARK 40, DEL.

NEW CHIKSAN DISCPAK SWIVEL JOINTS

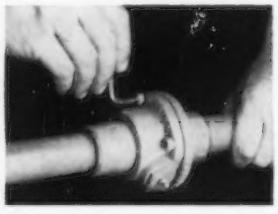


FOR STEAM AND HOT GAS SERVICE

Created specifically for service on lines employed in steam and hot gas service, the Chiksan Discpak embodies a new construction design which permits packing units to be replaced without removing the joint from the line. The outer housing of the Discpak is cut apart at the packing chamber and both ends are flanged at the cut. Four allen-type cap screw bolts are used to secure the flanges. A disc-seal, housed between the two members, provides a fluid-tight seal between rotating and stationary members of the Discpak Swivel Joint. A spring loaded pressure plate holds the packing in sealing position against the swiveling member.

The new Discpak has a maximum temperature rating of 600° F. and a maximum pressure rating of 300 psi. All turning movement in the Discpak takes place on a double row of precision ball bearings. Write today for literature and prices. If your plant or equipment lines utilize hot gas or steam, it will pay you to know about this new field-proven Discpak swivel joint.

REPLACE SEALS WITHOUT REMOVING JOINT FROM THE LINE



To replace the disc-seal, simply remove four allen screws and spread line slightly with a flat metal bar.

CHIKSAN

CHIKSAN COMPANY, 330 No. Pomona Avenue, Brea, California
A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

Please rush me a copy of your new Discpak Bulletin

NAME_____

COMPANY_____ TITLE_____

CITY_____ ZONE____ STATE_____

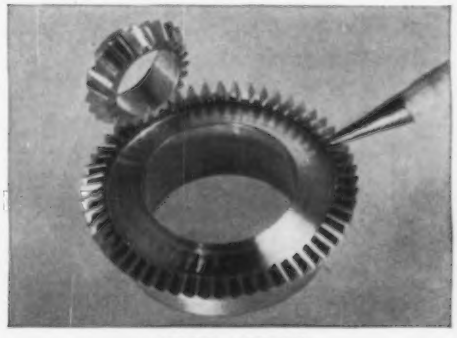
PLEASE ADDRESS DEPT. 201

SEND FOR BULLETIN

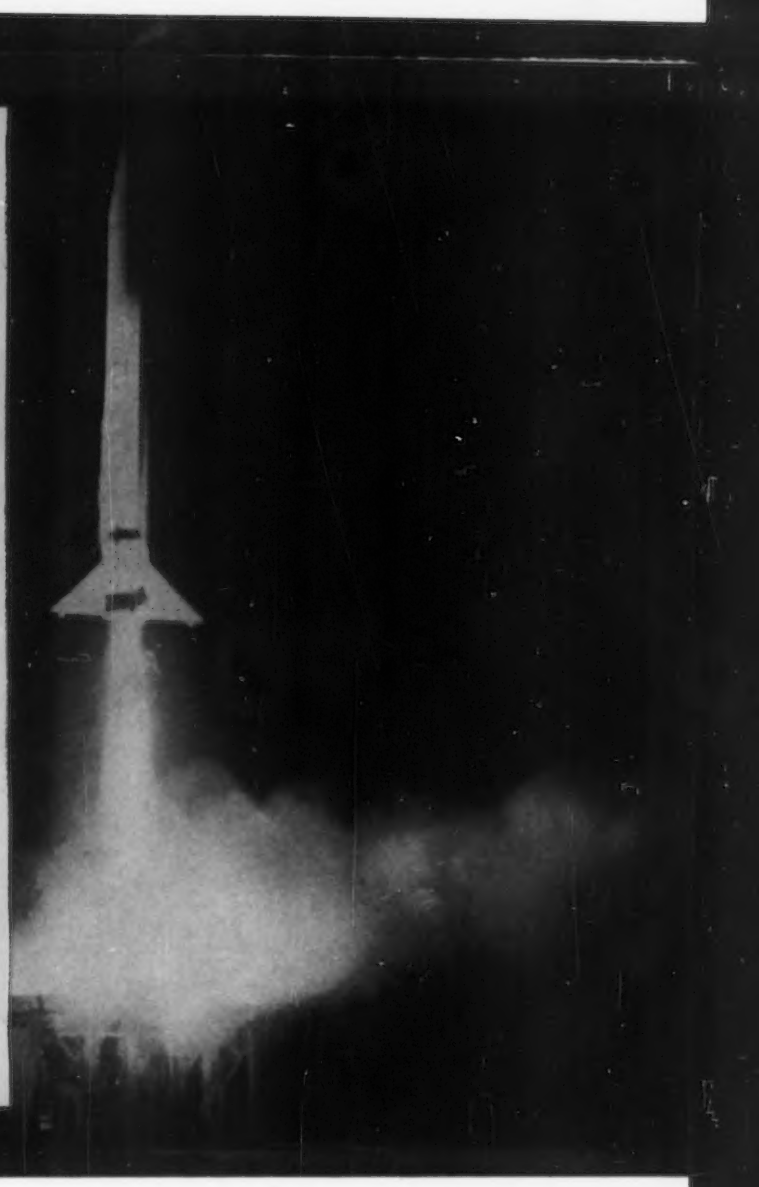
New Discpak Bulletin 100 describes in detail the many features of this new swivel joint including full mechanical specifications.

57-26

CURVIC COUPLINGS provide an accurate, light, compact, and self-contained connection in which the teeth both center and drive. The Curvic design represents a new standard in the application of coupled parts.



BEVEL GEARS



When a gear or a coupling determines the *accuracy of trajectory* . . .

When a missile or rocket works on paper the best way to get it into the air is to see to it that all the parts agree with the paper work.

And when one of those parts is a bevel gear or coupling, Gleason engineers can help you three ways:

1. Engineering service. Our full staff of engineers is ready at all times to help you develop bevel gear combinations and Curvic® Coupling designs. They can help you make sure that either part meets your specifications.

2. Machines to cut or grind to your tolerances. You can produce any fine pitch gear—spiral bevel, hypoid, Zerol® or Coniflex®—precisely and economically with any of five Gleason machines.

No matter how rigid your specifications or the size of your parts, our engineers can help you select the right machine or combination of machines for 100% accuracy.

3. Complete testing equipment. We have engineered a series of testers for making certain that all parts do meet your critical specifications. For example, on the Gleason No. 104 Hypoid Tester you obtain a permanent test record to help you match pairs properly and to keep a graphic record of the rolling qualities, tooth spacing, and concentricity of your parts.

Any or all of these services are yours for the asking at any time.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

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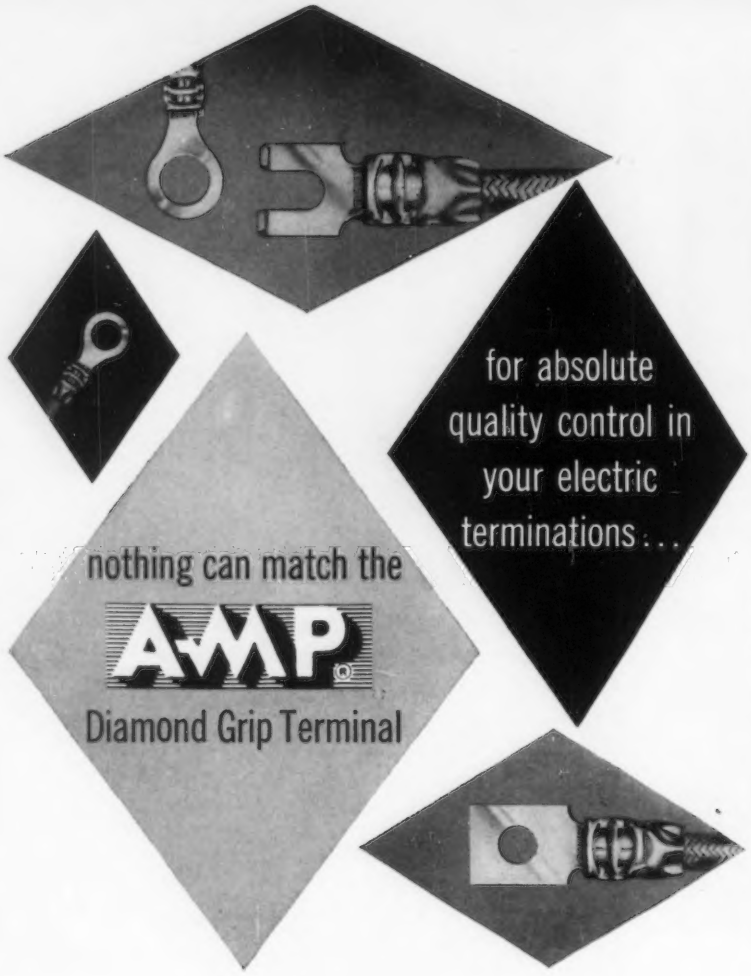

An endless parade of electrically perfect, wired terminals with absolutely identical performance characteristics is assured when A-MP non-insulated Diamond Grip terminals are used. No matter how many terminals you need, each action of the A-MP precision tool attaches a Diamond Grip terminal that gives firm, fully circumferential wire support, for maximum tensile strength, resists vibration and corrosion, while performing at maximum conductivity.

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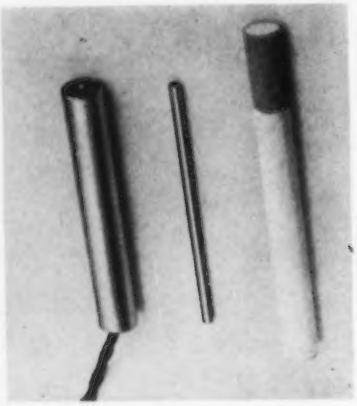
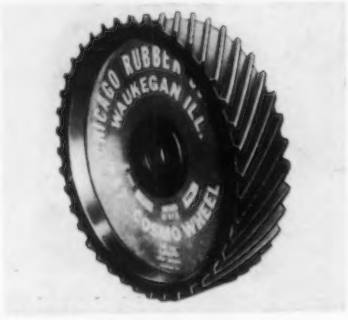
General Offices: Harrisburg, Pennsylvania

A-MP products and engineering assistance are available through wholly-owned subsidiaries in: Canada • England • France • Holland • Japan



is vacuum impregnated with a silicone varnish. Input is 1.5 v, 60 cps. **Automatic Timing & Controls, Inc., King of Prussia, Penna.**

Circle 32, inside back cover



Self-aligning contact wheel . . . for abrasive belts does not vibrate and needs no aligning even when spindles are worn. Molded-rubber arbor hub aligns by centrifugal force. Speed automatically centers wheel as it gains momentum. Available in 6-to-16-in. dia and 1-to-4-in. widths. **Chicago Rubber Co., Inc., Waukegan, Ill.**

Circle 33, inside back cover

Directional control valves . . . for hydraulic oil systems include six basic models: lever-operated, stem-operated, cam-operated, oil-pilot-operated, air-pilot-operated, and oil-pilot-operated with solenoid control. Three standard and five alternate spool styles are available. Most models are offered with a choice of four spool

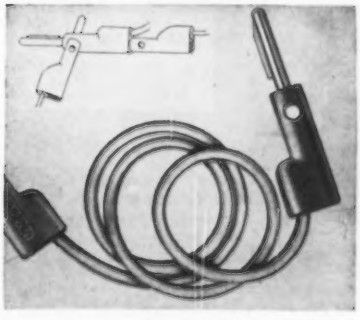
(Continued on page 127)

actions. Valves have interchangeable mounting dimensions and are suitable for systems to 300 psi. Valves have high-tensile alloy iron bodies with hardened and ground spools, chrome-plated and lapped. Pipe sizes are available in ¼-in. for 12 gpm flow and ¾-in. for 18 gpm flow. Dry-seal pipe threads are standard and a gage port for testing is provided. **Dukes Co., Inc., 3999 N. 25th Ave., Schiller Park, Ill.**

Circle 34, inside back cover

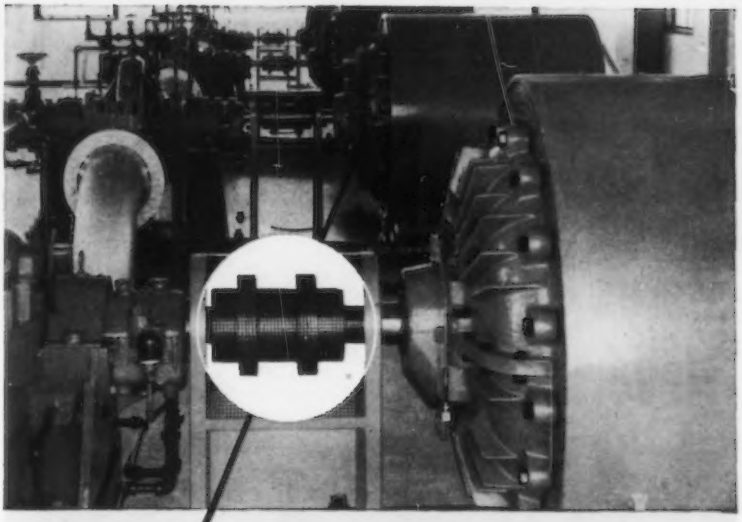
Panel instruments . . .
with clear plastic covers and 2½-in. long scales in a 100° arc are said to afford excellent readability and illumination from top, front, and sides of case. Lower case is a neutral-toned, prismatic surface designed to complement equipment or panels. Mechanisms used eliminate need for external shielding and permit close grouping on magnetic or nonmagnetic panels without special adjustments or danger of intereffects. Lance-type pointers are standard. Instruments are interchangeable with any 2½-in. JAN or military-specified unit. Dc models have accuracy of 2% of full-scale value; rectifier ac model has an accuracy of 3%. **Weston Instruments, Div. of Daystrom, Inc., Newark 12, N. J.**

Circle 35, inside back cover



Connecting lead . . .
is a flexible stranded wire, polyvinyl insulated, with an integrally molded plug. Reduces setup time for general-purpose hookup and interconnection of equipment,

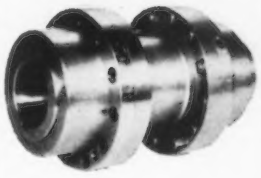
(Continued on page 129)



Waldron couplings in main line crude oil station

WALDRON

flexible couplings...



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same 3 reasons

1 STRENGTH—Hubs and cover sleeves for sizes 1¼A through 7A are machined from tough steel forgings. Hubs are keyed to the shafts. The two one-piece cover sleeves function as a single, rigid unit serving as a floating connecting link between the hubs. High strength of forgings makes possible a very compact coupling with low rotating inertia.

2 RELIABILITY—There are no flexible parts to bend or break and the coupling is dust, moisture, and oil tight. Patented Walflex seal is at the lowest possible diameter where centrifugal force is least. Clearance between teeth in hubs and sleeve is engineered so that an oil wedge always separates them, taking the wear.

3 SERVICE—Plenty of rough bore couplings, already assembled—on the shelf for *immediate* delivery. Finish bored standard couplings shipped to meet customers' schedules. We are geared up to give you realistic delivery on *any* type of couplings.

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ROAD
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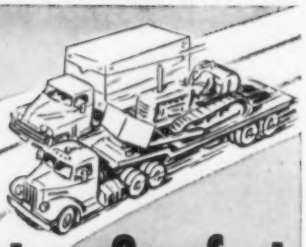

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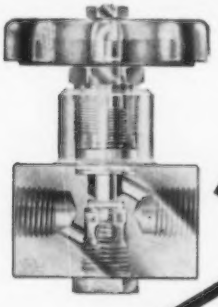

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A-C POWER SUPPLY SYSTEMS

- Complete Power Supply Package includes: belt-driven alternator, rectifier and regulator. Total weight is only 57 lbs.
- Good for applications such as lighting and heating on mobile equipment or in remote locations.
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Ask for GEC-1407; Write Section 634-19, General Electric Co., Schenectady, N. Y.

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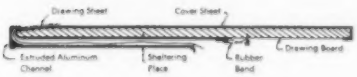
instrumentation work, breadboards and servo setups. Design, with side holes and stacking features, makes possible unlimited connections at any plug body. Spring-action tip is self-wiping with uniform resistance of less than 0.001 ohm. Compensates for wide variations in mating. Leads withstand a tensile force of 20 lb min and will resist failure caused by flexing at junction of plug and wire. In red, black, green, yellow, blue and brown. Fit all standard terminal posts, jacks, alligator clips and spade lugs. **Associated Engineering Corp., 65 Kent St., Brookline 46, Mass.**

Circle 36, inside back cover

Calibrated on-off cycles . . .

are achieved on this repeat-cycle timer by use of a multi-vibrator circuit with adjustable R-C circuits. OFF cycle is adjustable in 12 steps from 1 to 300 sec. ON cycle is adjustable continuously from 0.1 to 10 sec. Voltage regulation is incorporated for repeat accuracy of 1% or better regardless of line voltage or frequency. Timer operates on 105 to 125 v, 60 cps, 12 w. Output is a DPDT relay with each contact rated 15 amp, 115 v ac, noninductive. Housed in a 6-in. sq-steel cabinet with sloping front. **G. C. Wilson & Co., Huntington, W. Va.**

Circle 37, inside back cover



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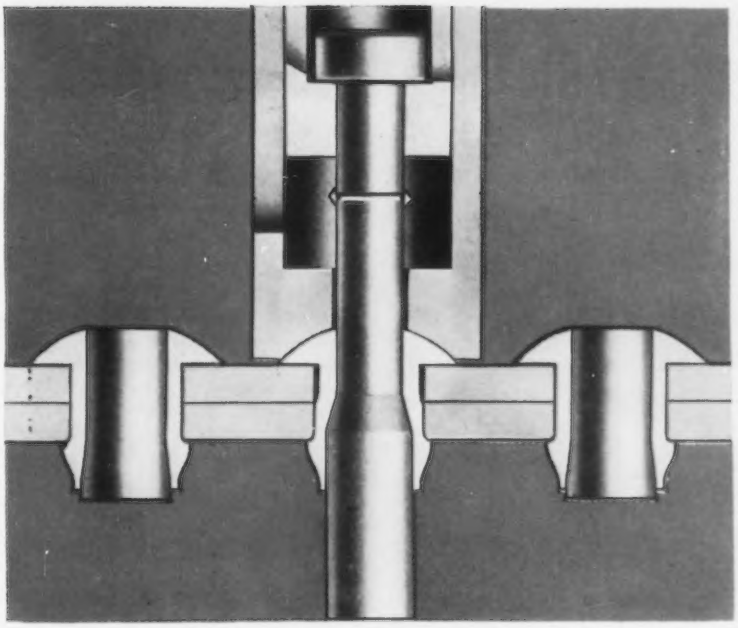
is an adjustable, folding surface that turns any desk or table into a drafting table. Drawing can be shifted from position to position on this board, which provides a sheltering place for the drawing when the draftsman is off duty. Also protects against smearing of drawing. Adjustable folding legs allow slant of board to be varied. Cover sheet is always under tension, eliminating wrinkling. Boards are ¾ x 31 x 42 in. or ¾ x 35 x 48 in. Prices range from $39.50 to $55. **Zee Co., P. O. Box 519, Church Street Sta., New York 8.**

Circle 38, inside back cover



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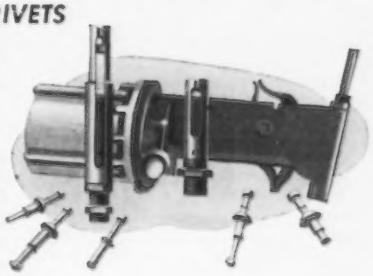
A FASTENING SYSTEM

CHERRY RIVETS • VERSA RIVETS

Townsend has engineered blind rivets and setting tools to create a simple, and therefore, economical fastening system. The patented knob stem of the rivet engages a pulling head in the gun which sets the rivet. This head has only two parts, and the rivet is set with a single squeeze of the gun trigger. Engagement of the knob stem is positive and quick even for operators without any special skills.

Pulling heads are extremely durable. The fit between draw-bolt and sleeve is comparatively free, so that wear is slight and tools can be used in the presence of dirt and grit with little danger of clogging. Uninterrupted production, long wear, and negligible maintenance are assured by this simple, sturdy design; and initial tooling costs are low.



Townsend knob stem blind rivets are available in a wide range of sizes and materials in both self-plugging and pull-thru types. Hand, air and electric powered tools can be supplied to meet any production conditions. For full details on the economical Townsend blind rivet system, ask for a demonstration or for Bulletin TL124. Townsend Company, P. O. Box 237-D, New Brighton, Pennsylvania.

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A-3-CW A-3-CCW	1/500	0.70	1.1	3360	3/8"
A-5-CW A-5-CCW	1/180	1.7	2.7	3430	5/8"
A-6-CW A-6-CCW	1/130	1.9	3.3	3430	3/4"
A-7-CW A-7-CCW	1/100	2.1	3.8	3500	7/8"
A-8-CW A-8-CCW	1/90	2.5	4.5	3480	1"
A-9-CW A-9-CCW	1/70	2.7	5.3	3520	1 1/8"
A-12-CW A-12-CCW	1/60	3.0	6.5	3500	1 1/2"
A-14-CW A-14-CCW	1/50	3.1	7.0	3490	1 3/4"

Standard shaft diameter .1817, 1/4" shaft available if desired.

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

HYDRAULIC EQUIPMENT—Loose-leaf combination of 16 pp catalog and about 68 spec sheets on gear pumps, cylinders and other hydraulic products. General specs, representative performance charts, dimensional drawings and illustrations are given. Mounting dimensions and repair parts are included. Industrial Products Div., Cessna Aircraft Co., Hutchinson, Kans.

Circle 39, inside back cover

COLD-FORMED METAL SHAPES—Handbook MS 158, 48 pp. Explains and illustrates basic principles of roller-die cold-forming of metal shapes. Material selection, roller dies, forming mills, tolerances for roll forming and typical metal shapes are covered. Van Huffel Tube Corp., Warren, Ohio.

Circle 40, inside back cover

LOCKNUTS AND FASTENERS—Catalog, 28 pp. Product descriptions, illustrations, dimensions, screw-tension ratings, materials, finishes, typical applications. Gives details of design and locking principle, high-speed wrenches and applicators, assembly and cost data. Palnut Co., 61 Glen Rd., Mountainside, N. J.

Circle 41, inside back cover

ELECTRICAL CONNECTORS—Bulletin 1252-1, 62 pp. Specifications and selection data on environment-resistant connectors. Also, connectors with delayed action to meet military specs. Includes wire tables showing allowable current-carrying capacities and other excerpts from NEC codes. Pyle-National Co., 1334 N. Kostner Ave., Chicago 51.

Circle 42, inside back cover

STANDARD MOUNTINGS — Bulletin 750C, 20 pp. Describes all mounting assemblies through engineering drawings and tabulated specs. Parts lists identify all parts furnished with standard worm and gear assembly. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12.

Circle 43, inside back cover

FOOTSWITCHES—Catalog 57, 4 pp. Lists more than 75 models of all types. Contact type, stage, pole, throw, phase, rating, size, weight and specific features are included for each switch. Linemaster Switch Corp., 432 Woodstock Terrace, Woodstock, Conn.

Circle 44, inside back cover

PHOTOELECTRIC CONTROLS—Catalog 58, 24 pp. Descriptions, applications and data on normal, high-speed, ultra-sensitive and impulse-actuated photoelectric controls. Also covers plug-in photoelectric controls, photoelectric and timing controls operated by the same phototube; light sources; electronic timers, and controls operated by current surge and impact. Autotron, Inc., Box 722 V, Danville, Ill.

Circle 45,, inside back cover

STANDARD NYLON PARTS—Bulletin 501, 20 pp. Nylon rollers, roller bearings, slide bearings and gears available from open stock are described with specs and dimensional drawings. Pipco International Corp., 1757 Stanford St., Santa Monica, Calif.

Circle 46, inside back cover

MECHANICAL POWER TRANSMISSION EQUIPMENT – Bulletin 7900-B1P, 12 pp. Contains selection charts for heavy-duty, lightweight and junior sheaves, V-belts, and variable-speed drives. Illustrated with dimensional drawings. Worthington Corp., Harrison, N. J.

Circle 47, inside back cover

FLUID-POWER DRIVES—Bulletin 10600, 32 pp. Explains advantages, operation and characteristics of variable, stepless speed transmission. Includes typical performance curves and block diagrams for various rotary applications. Curves cover speed control, synchronous operation of separate drives, reversing operation, controlled acceleration and deceleration, hydrodynamic and regenerative braking, torque and power, tension and torque control, and overload performance. Oilgear Co., 157-OV W. Pierce St., Milwaukee 4.

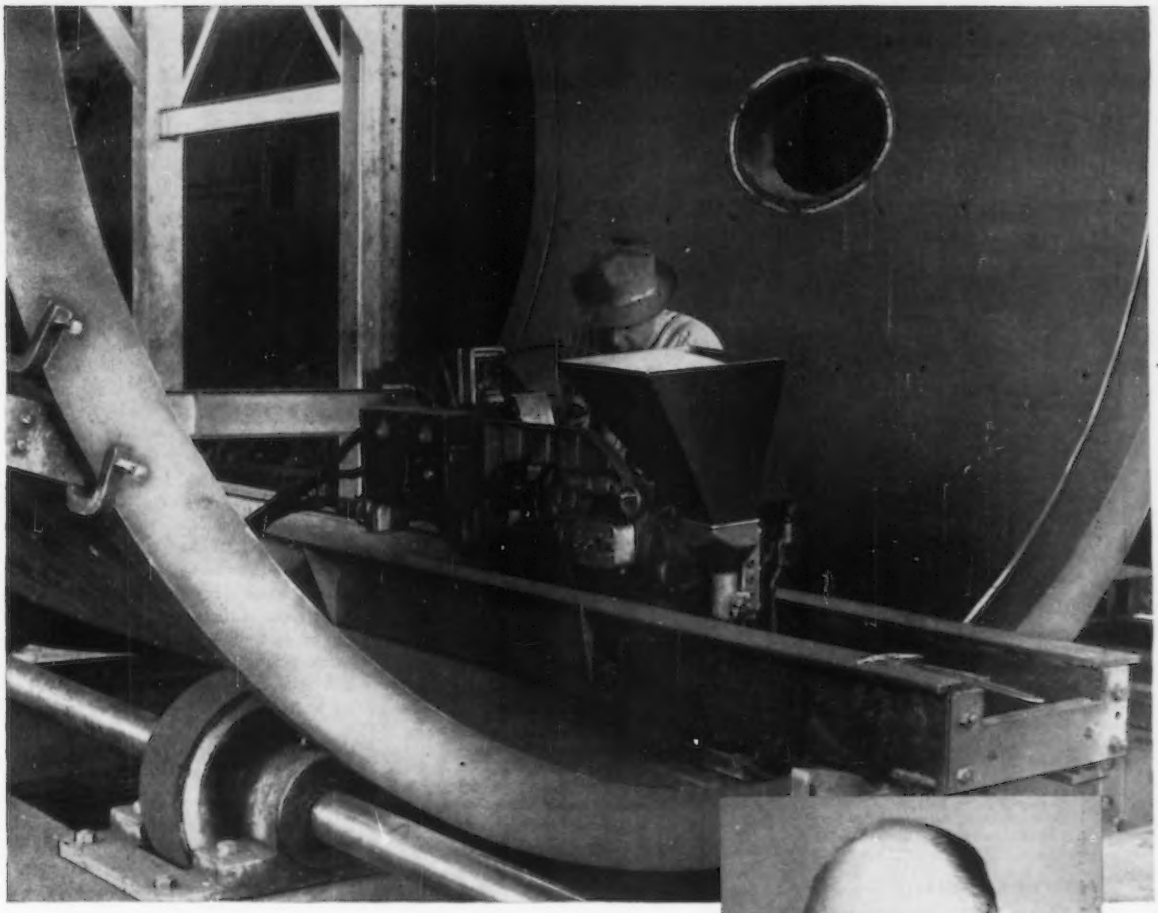
Circle 48, inside back cover

CASTER WHEELS—Bulletin 15, 2 pp. Describes properties that make these wheels non-sparking, nonflammable and resistant to abrasion and moisture. Photographs, sketches and drawings illustrate wheels, construction and uses. Tables provide specs. Rapids-Standard Co., Inc., 342 Rapistan Bldg., Grand Rapids 2, Mich.

Circle 49, inside back cover

SELF-LOCKING SOCKET SCREWS—Brochure, 4 pp. Contains specs and illustrations, lists standard sizes. Tables give location of self-locking pellet, type of

(Continued on page 132)



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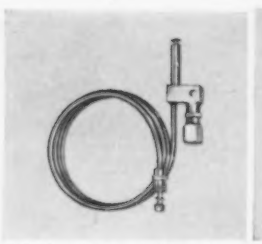

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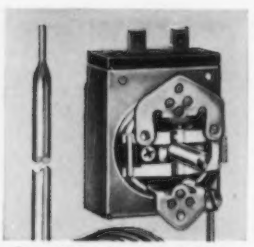

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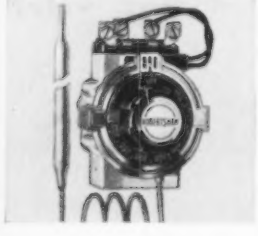

Steam controls for sterilizers, dish washers, urns, steam tables, etc.

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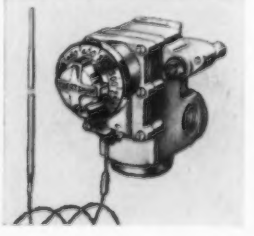

thread and locking torque for each fastener. Also describes operational principle. Cleveland Cap Screw Co., 4444 Lee Rd., Cleveland 28.

Circle 50, inside back cover

STOCK BELT DRIVES–Catalog TB-58, 68 pp. Engineering information on five basic belt pitches. Covers selection, installation and use of positive, lubrication-free drives. Indexed. Morse Chain Co., Ithaca, N. Y.

Circle 51, inside back cover

SHADED POLE MOTORS – Bulletin GEA-6134B, 12 pp. Contains design, dimension, rating, performance and application data. Includes several cutaway illustrations and diagrams. Bulletin is indexed. General Electric Co., Schenectady 5, N. Y.

Circle 52, inside back cover

PLASTIC RESINS–Booklet, 8 pp. Applications and physical-property data are condensed in this guide to company's resin line. Details are given on seven types of a resin-rubber blend and 12 types of vinyl resins. Naugatuck Chemical Div., U. S. Rubber Co., Naugatuck, Conn.

Circle 53, inside back cover

IMMERSIBLE MOTOR–Bulletin 2300, 4 pp. Construction is described and illustrated. Design data is included along with specifications and dimensional illustrations for applications involving water, chemicals, cutting oils. Louis Allis Co., Dept. P, 427 E. Stewart St., Milwaukee 1.

Circle 54, inside back cover

STANDARD TEMPLATES–Catalog, 8 pp. Illustrated list of templates that represent over 200 components for jigs and fixtures–in full scale. Northwestern Tools, Inc., 117 Hollier Ave., Dayton 3, Ohio.

Circle 55, inside back cover

OPTICAL PARTS–Catalog L-117, 16 pp. Describes unmounted optical parts,

(Continued on page 133)

"We may seem a bit inquisitive, but I want to reassure you we're not spies—"

including lenses, prisms and reflectors. One section describes quartz and other special optical parts. Each section has tables for ordering stock items by catalog number. Several outlines help research and manufacturing engineers describe their optical problems. Price list included. Bausch & Lomb Optical Co., Rochester 2, N. Y.

Circle 56, inside back cover

GLASS-BONDED MICA—Bulletin 101, 6 pp. Covers all types of high-frequency insulation materials for electric and electronic devices. Descriptions, technical data and properties. Electronic Mechanics, Inc., 101 Clifton Blvd., Clifton, N. J.

Circle 57, inside back cover

WEATHERPROOF AND EXPLOSION-PROOF HOUSINGS—Bulletin B-158, 16 pp. Selection and specifications for cast aluminum housing. For each housing listed, dimensional information and technical data are grouped with photos and drawings. Sealing fittings are also included. Adalet Mfg. Co., 14300 Lorain Ave., Cleveland 11.

Circle 58, inside back cover

CHEMICAL TREATMENTS OF METALS—Brochure, 8 pp. Describes chemical-conversion coatings for steel, aluminum, galvanized iron, zinc and cadmium-plated surfaces. Also listed are current specs for Government and its contractors. American Chemical Paint Co., Ambler 1, Penna.

Circle 59, inside back cover

GEAR HEADS AND SPEED REDUCERS—Catalog, 8 pp. Descriptions, general specs, dimensional drawings and information. Washington Machine and Tool Works, Inc., 13111 Wayzata Blvd., Minneapolis 26.

Circle 60, inside back cover

DIGITAL CONTROL AND INDICATION—Bulletin, 4 pp, describes five new components for use as digital actuators and feedback devices in servo and instrumentation systems. Block diagrams of servo and measurement systems are presented with illustrations. Principle and application of system are discussed. Anatran Corp., 45 W. Union St., Pasadena, Calif.

Circle 61, inside back cover

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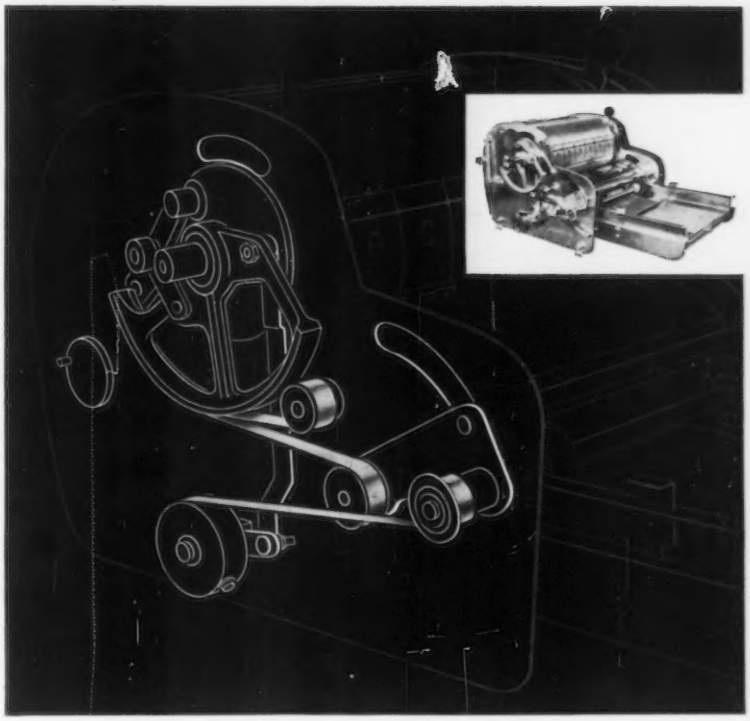

Transmit Motion Without Backlash

USING A NEG'ATOR® SPRING

Quiet, gearless transfer of motion without slippage or backlash—still another function of Hunter's versatile design component, the NEG'ATOR constant-tension Spring.

Searching for a gearless method to link and synchronize the action of paper handling rollers to the timing drive assembly on the new "ROCKET" duplicating machine, design engineers at Standard Duplicating Machines Corp. tried cords, cables, chains—found that NEG'ATOR Springs outperformed all.

So, as illustrated, they attached the free ends of two NEG'ATORS to the cam-and-lever driven timing segment and the free end of a third NEG'ATOR to an idler pulley. The constant tendency of the NEG'ATORS to return to their original coiled condition when extended keeps them taut—eliminates backlash. They rewind smoothly on the drive pulleys as the pulleys are returned, under spring tension, to the cycle starting position.

By replacing gear trains with NEG'ATORS, Standard's engineers obtained efficient operation, longer life, quieter operation, and reduced unit cost. The "ROCKET" is said to be the "quietest machine on the market."

Used in the manner described or to counterbalance without mass, maintain constant pressure, deliver retracting force, power portable units, expand a scale, or perform other functions, the constant-tension NEG'ATOR Spring might offer just what you're looking for.

You can learn more about the NEG'ATOR, its characteristics, forms, functions, and applications by reading Bulletin 310N. Send for a copy.

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Tangents...

The Little Things

There was new snow—eight melting inches of it—and the cars had stood at the side of the mountain road all night in it. The little foreign cars started, the old American cars started, but my relatively new, highly mechanized one didn't. Turned out that the automatic choke was stuck, the automatic shift was sticky, the automatic window washer was clogged, and one tire was leaking. This modern tubeless, puncture-resisting tire had been punctured by an old-fashioned carpet tack about ½ in. long, embedded between treads! The tack came out easily, but the air came out with it.

Back inside the lodge, the wife of a college professor was talking. "I'll never buy another.....appliance!" she said. "The controls on my new oven stick, the thermostat is not accurate, and the door doesn't close tight. The service men can't even fix it."

Then others, men and women, talked of troubles with lawn mowers, tractors, pumps, air conditioners, mixers, *et al*, meantime looking accusingly at the only engineer in the group: yours truly.

What defense would you offer? Here were people who had bought, in good faith, the gadgets for which modern America is justly famous. And in case after case, the handles broke, the toast was burned, fertilizer was spread unevenly, or some similar mechanical failure made the gadget a headache rather than a help.

There was a singular similarity among the cases quoted—a good product of excellent reputation malfunctioning because of a minor accessory, a detail. Basic design was sound, but a small component, frequently a purchased one, was affecting operation—hence reputation—of the whole product. The criticism was not leveled at the detail, but at the basic design.

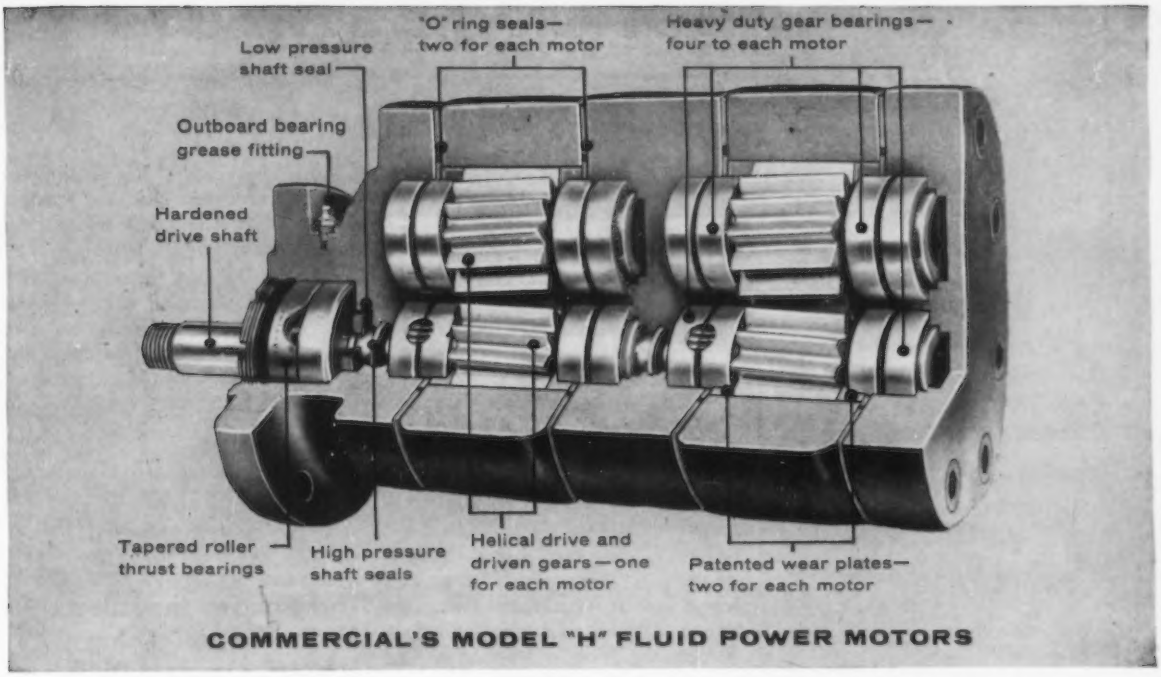
This malfunctioning of components is nothing new to equipment makers; it has plagued them for years. All sorts of explanations are given: bad work by component suppliers, improper or careless assembly, faulty inspection, mistreatment by the buyer, damage in shipping. But only infrequently is the real reason brought out—that design has been shaved to the last fraction of a cent. Thus parts are bought because they are cheaper, not because they're better, and are installed by men who have no pride of workmanship. The craftsmanship that characterized hand manufacture disappears in volume production; only by exceptional change in methods can it be regained.

Note that while most of these irritating failures result from production difficulties, they are in general assessed against design. Thus it behooves the design engineer to be conscious of what can go wrong in production, to produce a design incorporating simple, reliable and easily maintained parts (or parts so enclosed that foreign objects can't get at them, so maintenance isn't necessary). In the choke mentioned originally, a metal cam is so thin that it can lock behind the screw follower. The nozzles for the windshield jets are not designed to be self-clearing. The same car shows other faulty details: door handles that are streamlined on the outside but sharp on inner edges, a radio "off" plunger that can be cocked and jammed because clearances are too great, molding-joint cover clips that snap off, a glove-compartment latch that vibrates out of adjustment and allows rattling, rear-deck parts with burrs exposed to scratch the unwary hand, trunk-compartment liners that fall loose, spare-tire lock bolt with rolled threads so short the wing nut runs off them onto the shank, and so on *ad infinitum*.

None of these mean anything in operation of the vehicle, except as a result of nervousness generated in the operator. But the sum of them may be selection of some other make the next time. The same goes for the other products with their faulty gadgetry. Typical is the repeated statement that it costs 30 to 40% of first cost to maintain a TV set.

Evidence is piling up that the consumer is sick and tired of products with built-in obsolescence, and he'll react with a buyers' strike—if he hasn't already.

—EJT


Low pressure shaft seal
"O" ring seals—two for each motor
Heavy duty gear bearings—four to each motor
Outboard bearing grease fitting
Hardened drive shaft
Tapered roller thrust bearings
High pressure shaft seals
Helical drive and driven gears—one for each motor
Patented wear plates—two for each motor

COMMERCIAL'S MODEL "H" FLUID POWER MOTORS

New ideas in fluid power motors

Multiple-speed drive simplified

Efficient operation of heavy mobile equipment frequently involves multiple speeds. Not so efficient, however, is the shifting of gears, the power take-offs, clutches and gear transmissions involved in gaining these desired speed levels with mechanical drives—not to mention the constant maintenance headaches these same drives entail.

Pictured above is one Commercial fluid power oil-hydraulic motor that now delivers low and high speeds efficiently—completely eliminates the problems mechanical drives ordinarily involve.

Two motors work in tandem

This Commercial Model "H" tandem motor actually involves two single motors of equal output mounted on one common drive shaft. When fluid power from the pump source is directed by simple valving into just one of the single motors, the shaft rotates at the high speed. The other single motor on the same shaft receives no input and therefore merely turns. When low speed is required, the total fluid power delivery from the pump is valved into both of the single motors. And of course motor torque at this reduced speed is doubled. This simplified control of two speeds—both low and high—is possible in either direction, forward or backward.

Each of the single motors in this Model "H" tandem motor has one-inch gears. With a fluid power input of about 15 gpm at 1200 psi, for example, when one of the single motors receives the entire input, rotation is 1200 rpm. When the same input is split between the two equal size single motors, rotation is 600 rpm.

Model "H" motors are available with gears in widths of 1", 1¼", 1½", 2", 2½" and 3". Any combination of gear sizes is practical.

More than two speeds

Even three speed operation can be obtained with Commercial double tandem motors when gears of different widths are used in each single motor. High speed operation results when the full pump delivery is valved to the motor with the smaller gears, intermediate speed when it is all directed to the larger gear motor, and slow speed when valved to both motors. One single motor having three-inch gears operating at 1600 psi at a speed of 1200 rpm would develop about 50 h.p. Commercial Model "H" motors are recommended for continuous duty operation at pressures up to 2000 psi and speeds up to 1800 rpm.

Engineering help available

Be sure to send for your copy of Commercial's "Oil-Hydraulic Motors Catalog H-4". Further information on Commercial's complete line of other fluid power components—valves, pumps and cylinders—is also yours for the asking, as is technical help and assistance from Commercial on fluid power applications.

Address inquiries to The Commercial Shearing and Stamping Company, Dept. G-12 Youngstown 1, Ohio.

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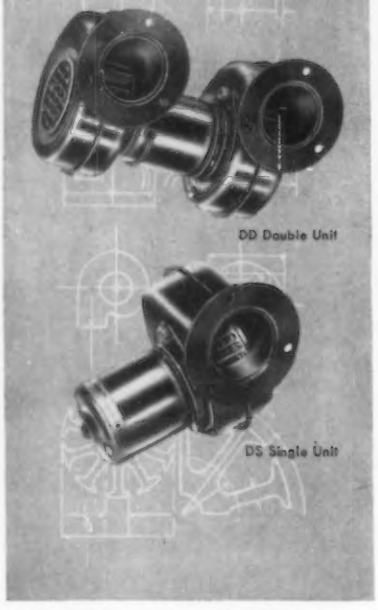

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long life
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Single or double blowers, with durable metal housing, are powered by type D shaded pole induction motor. Rugged units require little oiling, won't interfere with radio or TV. Standard operation is on 115 V, 60 cycles, AC. Single unit has load speed of 3200 rpm, 55 cfm; double unit operates at 3100 rpm, 100 cfm. Other frequencies and voltages available.

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HEINZE ELECTRIC COMPANY
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SUB-FRACTIONAL HORSEPOWER MOTORS AND BLOWERS

DESIGN ABSTRACTS

Atomic Radiation in Plastics Technology

Problems of applying radiation to improve properties and characteristics are (1) radiation does not perform any reaction that cannot be achieved by conventional chemical methods; (2) cost of radiation processes will continue to decrease for years, while cost of chemical catalysts has leveled off, and may even increase; (3) chemical accelerators will be found to make more efficient use of radiation and lower costs; (4) technology of applying radiation will be extended and refined if research demonstrates it is preferred tool. It is concluded that radiation will play an important future role in polymerization, vulcanization and graft copolymerization.

Abstracted from "Role of Atomic Rediation in Plastics Science and Technology," by R. F. Boyer and R. McFedries, Dow Chemical Co., SPE paper 2, 14th Annual Technical Conference, Detroit, Jan. 1958; SPE, 34 E. Putnam Ave., Greenwich, Conn.

Brittleness in Polyethylene

Occasional brittleness in early polyethylene suggested an investigation of possible causes by a chemical-research group. A biaxial-elongation test and other experiments showed that specifying compounds of higher molecular weight improved fracture resistance. Absence of branches in molecular structure of polyethylenes also benefits mechanical performance.

Abstracted from "Brittleness in Polyethylene," by I. L. Hopkins, Bell Laboratories Record, Jan. 1958, 463 West St., New York 14.

Axial Vibration and Noise in Ball-bearing Motors

Main form of vibration is caused by distortions and discrepancies of outer bearing race. Axial mode of vibration consists of rigid motor frame and rotor vibrating in opposition, with ball bearings acting as nonlinear connecting spring. It was possible to accentuate some nonharmonic vibrations by minimizing damping in system.

For a given design, axial natural frequency can be calculated, and a simple bump test will check such calculations. A loose sliding fit on both ball bearings, so that motor frame and rotor are not spring-coupled, prevents axial resonance from materializing. A wavy washer or rubber O-ring, having a low spring constant and exerting a small thrust load also improves system.

Abstracted from "Axial Vibration and Noise in Ball-bearing Motors," by E. C. Fischer, Westinghouse Electric Corp., AIEE paper CP58-200 (Winter meeting, New York, Feb. 2-7), 33 W. 39th St., New York 18.

Three-phase Induction Motor Control Using Static Frequency Doublers

This system employs static frequency doublers, combining benefits of static switching and power modulation. Power obtained from a given size of machine is doubled and a high-speed drive direct from motor shaft is obtained. System may be made inherently torque limiting at any torque value less than pull-out torque of motor. Speed control over increased range is obtained by varying rotor resistance, in combination with appropriate variation in control current for class of load.

Abstracted from "Three-phase Induction Motor Control Using Static Frequency Doublers," by A. Straughen, P. P. Biringer, G. R. Sleman, U. of Toronto, AIEE paper 58-68 (Winter meeting, New York, Feb. 2-7), 33 W. 39th St., New York 18.

Reprints of three articles . . .

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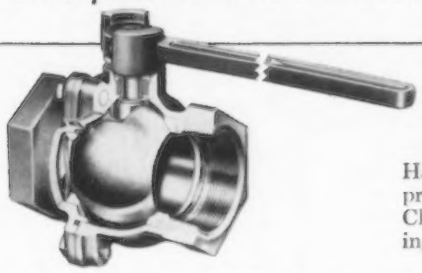
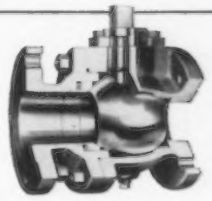


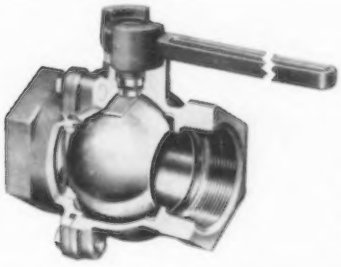
NEW ROCKWOOD STEAM VALVE WITH THE ABOVE BALL VALVE ADVANTAGES

Handles steam up to 125 lbs. P.S.I. and 350°F, with ease. It's leakproof, stays tight. Opens and closes quickly — only ¼ turn needed. Chrome-plated bronze ball resists wear, abrasion, pitting and scratching. Less maintenance needed.

ROCKWOOD STAINLESS STEEL BALL VALVE

⅜" to 2" (including 3" and 4" flanged valves). Made of stainless steel that meets fully all the requirements for steel pressure castings as embodied in ASTM. These Rockwood ball-type valves are designed and constructed for superior service. They combine the best features of plug cocks and globe valves.





ROCKWOOD REGULAR BRONZE VALVES

Made of bronze with screwed ends in all pipe sizes from ⅜" to 2½" and in cast steel 3" and 4" flanged ends, recommended for 300 P.S.I. working pressure.

Opens and closes with a quarter-turn. Handle design allows valve to be installed in any position assuring clearance in all types of installations. Full floating ball does not depend upon mechanical parts to maintain proper alignment of ball and seat. Tested and listed by Underwriters' Laboratories, Inc.

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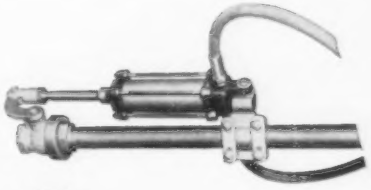
To operate valves in hazardous locations or in hard-to-get-at places, Rockwood offers you the new air-operated Ball Valve. This new unit can be mounted in FOUR different positions around the Rockwood Ball Valve. It operates the valve smoothly and efficiently. One valve or several valves can be controlled from one central control board. Available in a complete package unit — ball valve, cylinder, special handle attachment and mounting bracket. Cylinder, handle and mounting bracket can also be bought separately to be attached to valves already installed on line. Can be operated with various types of controls.

This complete package unit is available in sizes from ½" thru 2" in bronze and 3" and 4" in cast steel.



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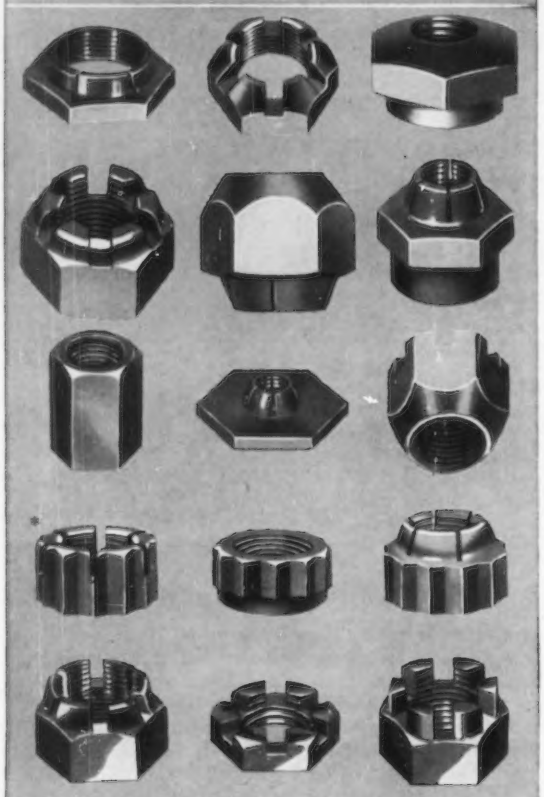

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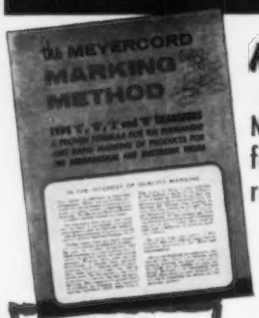

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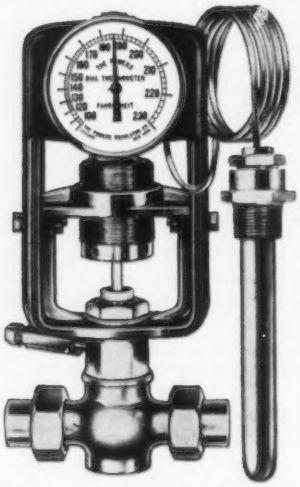

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NEW BOOKS

Technical Mathematics With Calculus

HAROLD S. RICE and RAYMOND M. KNIGHT, *Mathematics Dept., Wentworth Institute, Boston, Mass. Published by McGraw-Hill Book Co., Inc. 330 W. 42nd St., New York 36. 6x9, 793 pp. $7.50.*

This book is a response to instructors of engineering subjects who feel their students need a calculus background. It is an introductory mathematics text written for post-secondary students who intend eventually to enter engineering. The authors prepare the student not only to work closely with the artisan, but also to be at ease in the precise atmosphere of engineering.

The material is identical with that in the same authors' "Technical Mathematics," except that three chapters on calculus have been added.

In the calculus section, considerable space is devoted to graphical differention and integration. The authors use this graphical method to introduce the basic principles of the calculus.

This text is limited to a treatment of arithmetic, methods of computation, intuitive geometry, classical algebra, trigonometry, periodic motion, a brief treatment of analytical geometry, vector algebra, and an introduction to the techniques of differential and integral calculus. Rational processes are emphasized and mathematical rigor is maintained throughout.

Timber Design and Construction Handbook

Prepared by Timber Engineering Co., Affiliate of the National Lumber Manufacturers Ass'n. Published by F. W. Dodge Corp., 119 W. 40th St., New York. 6x9, 622 pp. $12.75.

This handbook was prepared by the Timber Engineering Co., engineering and research affiliate of the National Lumber Manufacturers Ass'n. It is a compilation of basic reference material for designing and building in timber. Over 4½ years of work by 26 leading specialists in timber engineering, designing and wood technology are said to have been put into this

(Continued on page 141)

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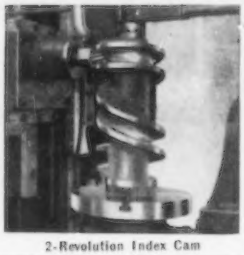

2-Revolution Index Cam

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volume. It includes material never before in print and consolidates information previously published, but scattered over many sources.

Evaluation of Dry-film Lubricant Coatings

MAJOR W. C. HART and BERNARD RUBIN, *Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. Available from Office of Technical Services, US Dept. of Commerce, Washington 25, D.C.* 8x10, 38 *pp.* $0.75.

The endurance and load-carrying capacity of commercial and experimental dry-friction reducing films have been investigated at low surface-rubbing speeds in the Falex Lubricant Tester. This investigation indicates that the most successful types of dry film lubricants have excellent extreme-pressure properties and good anti-wear properties for plain bearing applications at low speeds.

Baked resin-bonded films have endurance life superior to that of air-drying spray and dip coatings. Endurance life and load-carrying ability of dry film lubricants is dependent on resin-bonding agent and pretreatment of metal surface prior to application. Max endurance life is obtained if both surfaces are dry-film coated.

Acoustics

JOSEPH L. HUNTER, *John Carroll U. Published by Prentice Hall, Inc. 70 Fifth Ave., New York 11.* 6x9, 407 *pp.* $8.50.

The first part of this book covers fundamentals of wave and vibration theory including an introduction to mathematical methods, terminology, and acoustics notation. The second part applies these principles to acoustic components: loudspeakers, microphones and recording systems. Also covered in detail are architectural acoustics, measurement apparatus, ultrasonics, underwater sound, speech, hearing and noise intelligibility.

The author, who is a professor of physics at John Carroll, states he had three important objectives in organizing and writing this book: (1) to give the reader a solid introduction to fundamental acoustics, which is really equivalent to a study of wave propagation in material media; (2) to acquaint the reader with operation and design of modern acoustic apparatus and the problems of present-day acoustics; (3) to provide background and technical proficiency necessary to understand acoustical writing.

Liberal use is made of fully worked-out illustrative problems. These include several typical design problems in the chapters on applied acoustics. Throughout, equivalent circuits are used as a basis for design problems, to show how these arise from the physical statement of the problems.

Mechanical Refresher—2nd Ed.

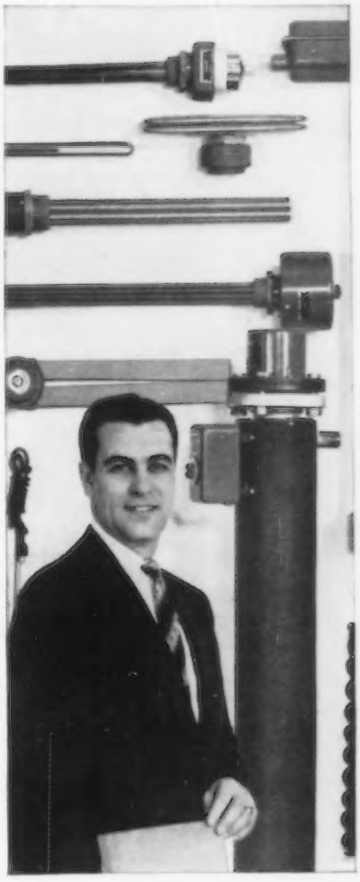
JOHN D. CONSTANCE, *P. E., Published by John D. Constance, 625 Hudson Terr., Cliffside Park, N. J.* 8½x10½, $3.

This volume is intended to aid professional-engineering-license candidates in preparing for examination in the various states. Engineers with long experience seeking license by endorsement can use this book to prepare for the oral examination. Where refresher courses are inaccessible or inconvenient, the candidate can use this book and its companions as a home-study refresher course.

The contents are expanded and rewritten in this new edition; the book originally appeared in a text written primarily as lecture notes used by the author in a series of refresher courses sponsored by the ASME in New York City. About half again as many problems are now included and colored index pages have been provided for more rapid use in the exam room.

"I'd suggest you use a 75S alloy for that, son. It has a typical tensile of 82,000 PSI and—yield of 72,000 PSI—which makes it perfect for speed rotating parts where the magnitude of the stresses is directly proportioned to the density of the material."

Liquid Heating Problems?



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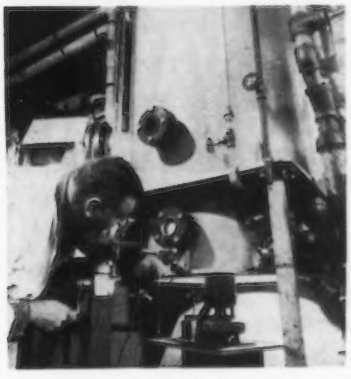
*REG. U.S. PAT. OFF.

Bendix
ELECTRIC FUEL PUMP
BENDIX AVIATION CORP. (Eclipse Machine Div.), Elmira, N.Y.

PRESS PREVIEWS

New Radome Test Lab Opened

A private facility for pretesting reinforced plastic radomes has been opened by Zenith Plastics Co., Gardena, Calif. Up to 18 radomes can be tested simultaneously from the three-story master control center with its six radially dispersed testing towers. Primarily intended to test production-line radomes designed and manufactured at Zenith, the setup has sufficient capacity to accept, on a rental basis, radomes of other manufacturers for transmission, reflectivity, beam-bending and pattern-distortion tests. In addition, special tests can be run to determine dielectric constants and loss tangents for basic materials prior to their use in radome manufacture.



Motors Operate Submerged In High-Octane Fuel

Westinghouse's new test facility at its Lima, Ohio, aircraft-equipment department evaluates performance of aircraft fuel-pump motors while submerged in high-octane fuel under simulated conditions of altitude, heat and cold. The lab consists of three isolated rooms that house test tanks, instruments, metering devices and auxiliary equipment, and an outside facility for storing the fuel.

Heart of the lab is the test room that contains two tanks, each capable of testing separately two motor-pump combinations. Each tank has an upper and a lower chamber separated by a steel plate having a 12 by 18 in. cutout. Motor-pump units to be tested are mounted in the top chamber. Each tank can be flooded with 165 gal of high-octane fuel and is equipped with coils to heat or cool the fuel.

During a test, the lower chamber is not flooded with the fuel; it remains dry. A door on the bottom of this chamber allows access to the face of the pump for making power and thermocouple connections. This door is equipped with a suitable counterweight and is latched by eight swing-type ball-handle bolts. Pressure cutouts will shut off power to any motor under test in the event of a drop in pressure. Level controls prevent overfilling the tanks.

New Company to Specialize in Microwave Tubes

A new company has been formed to deal in research, development and manufacture of electron devices. The firm, Watkins-Johnson Co, expects to locate laboratory and manufacturing facilities in Palo Alto, Calif. and will specialize in microwave tubes. Dr. Dean Watkins, president of Watkins-Johnson, indicated an employment of between 50 and 75 persons.

"We're way ahead on the drawing board . . . But we're still in the experimental stages out here. . . ."

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Specify LimiTorque ACTUATORS

LimiTorque actuators are efficient, sensitive, automatic heavy duty power-operated units for *positioning machine parts or other assemblies requiring Linear or Rotary Motion.*

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Mac-it Hollow Set Screw
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Mac-it Button Head Socket Cap Screw
Mac-it Socket Head Cap Screw

Here's a cost-saving tip — don't specify or buy screws on first cost alone. Evaluate the lifetime cost—it can mean substantial cost savings.

For applications requiring utmost strength and dependability, Mac-it Socket Screws have the lowest lifetime cost. This can save you money through:

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BETTER PERFORMANCE—because of Mac-it's greater resistance to punishment.

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Browning Manufacturing Company, Maysville, Kentucky.

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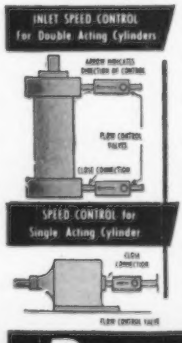
Pneu-Trol VALVES

★ **Accurate, Constant Cylinder Speed Control**
★ **Compact Rugged Design**
★ **Simple, Easy Speed Selection** ★ **For Air, Oil or Water Applications**



Pneu-Trol Speed Control Valves, are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

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Three articles from this issue have been reprinted and are now ready for distribution:

Textured Steel

Mar. 17'58, p. 73. Types available; when, where and how to use it; two new processes. **Circle No. E15**

Which Adhesive for What

Mar. 17'58, p. 79. How to apply them and to what metals; with data tabulated for fast reference. **Circle No. E14**

Exotic Metals

Mar. 17'58, p. 66. Design data on nine "rare" metals with valuable though tantalizing properties. **Circle No. E13**

While the supply lasts, single copies of the following reprints from earlier issues are also obtainable with the Reader Service Card:

7 Ways to Start High-Inertia Loads

Mar. 3'58, p. 75. Large table analyzes relative performance of each basic method, as an aid in matching a specific load condition. **Circle No. E12**

Finishes for Die Castings

Mar. 3'58, p. 59. Graphical guide to selection of mechanical, chemical, plating, painting. **Circle No. E11**

Which Way to Make a Cam

Mar. 3'58, p. 67. A recognized authority shares his experience by means of a tabulation covering characteristics of 31 methods. **Circle No. E10**

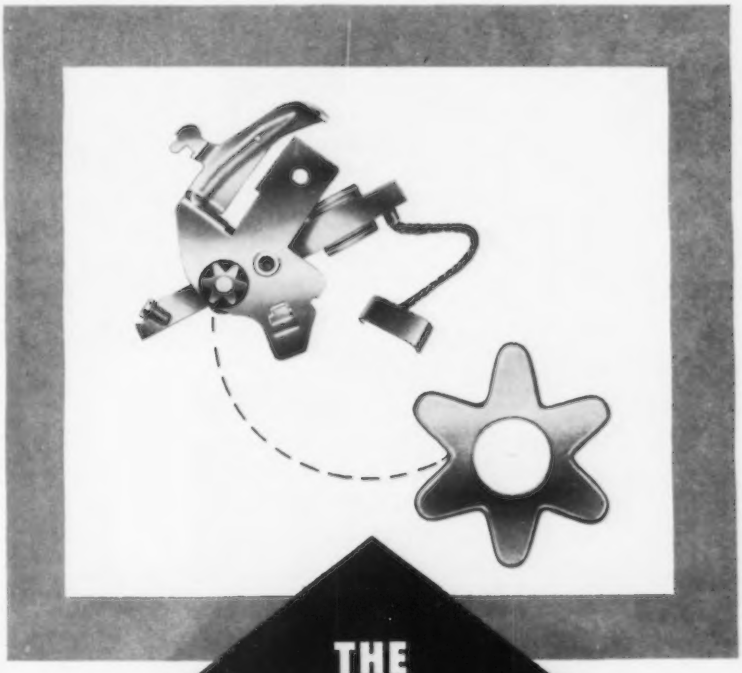
Porcelain Coatings on Steel

Feb. 17'58, p. 75. New enamels and better process control now permit one-coat porcelain on ordinary cold-rolled steel. **Circle No. E9**

Post-formed Phenolics

Feb. 17'58, p. 66. How to design for

(Continued on page 147)



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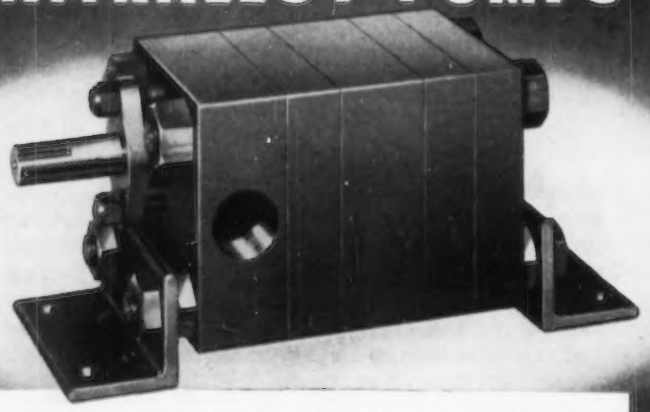

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Feb. 17'58, p. 83. Analysis discloses advantages of tapered sections; equations for four variable-section types compared with straight cantilever. Circle No. E7

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Feb. 3'58, p. 50. First design data on applications for this high-grade etching process for large-scale production of parts other shaping methods can't handle easily. Circle No. E6

Multi-rate Helical Springs

Jan. 20'58, p. 76. A variety of methods that give an increasing or decreasing deflection rate. Circle No. E5

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Jan. 20'58, p. 70. Wide range of core materials now available with detailed comparative data. Circle No. E4

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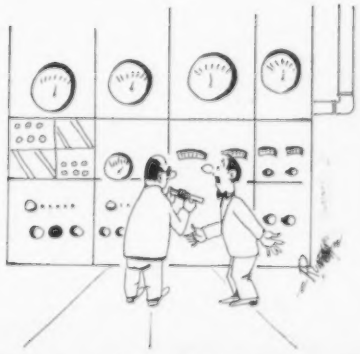

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E7. Which Cantilever Boom Is Best
Equations for four variable-section types

E8. Post-formed Phenolics
How to cut cost using pre-laminated sheet

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One-coat enamels for ordinary cold-rolled steel

E10. Which Way to Make a Cam
Tabulation of design data on 31 methods

E11. Which Finish for Die Castings
Design guide to mechanical, chemical, plating, painting methods

E12. 7 Ways to Start High-inertia Loads
Table presents performance of each basic method

E13. Exotic Metals Seek Employment
Complete property data on nine tantalizing "rare" metals

E14. Which Adhesive for What
Design guide and fast-reference table with application data

E15. Textured Steel
New processes, texturing methods, design data and trends

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MORE DATA ABOUT COMPONENTS AND MATERIALS

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DESCRIPTION OF THESE NEW ENGINEERING

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38—Slide Drawing Board

NON-METALLIC MATERIALS, FINISHES

5—High-density Polyethylene

15—Thermoplastic Sealant

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DESCRIBED ON PAGES 130-133

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55—Standard Templates

NON-METALLIC MATERIALS, FINISHES

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53—Plastic Resins

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FABRICATION PROCESSES AND PRODUCTION

40—Cold Formed Metal Shapes

POWER TRANSMISSION

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51—Stock Belt Drives

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MECHANICAL PARTS

43—Standard Mountings

46—Standard Nylon Parts

56—Optical Parts

49—Caster Wheels

58—Explosionproof Housings

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PARTS, MATERIALS AND FINISHES . . .

ITEMS APPEAR ON PAGES 103-129. CIRCLE KEY NUMBER FOR ADDITIONAL INFORMATION.

POWER TRANSMISSION
24—Electromagnetic Clutches
25—Shunt-wound Dc Brake
25—Miniature Clutches and Brakes
26—Miniature Magnetic Brakes

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2—High-capacity, Low-cost Bearing
9—Two-piece Rod End
31—Hardened Standard Ways
33—Self-aligning Contact Wheel

FASTENING AND JOINING
4—Self-sealing Screws
23—Self-locking Anchor Nuts
30—Studs and Inserts

MOTORS, ENGINES AND CONTROLS
3—High-speed Non-reset Counters
14—Shorter Pancake Motor
6—250 kc Plug-in Circuits
13—Speed Control
16—Planetary Gear Motors
20—High-speed Reset Counters
21—Electronic Timer
27—Explosionproof Timer
29—Dc Voltage Regulators
32—Displacement Transducer
35—Panel Instruments
37—Calibrated On-off Cycles

ELECTRICAL, ELECTRONIC COMPONENTS
8—Thermal Circuit Breaker
12—General-purpose Relay
11—Molded Terminal Boards
15—Load Control Relay
17—Remote Control Switch
19—Three-wire Cordsets
22—Lighted Pushbutton
36—Connecting Lead

HYDRAULIC, PNEUMATIC EQUIPMENT
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41—Locknuts and Fasteners
50—Self-locking Socket Screws

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54—Immersible Motor
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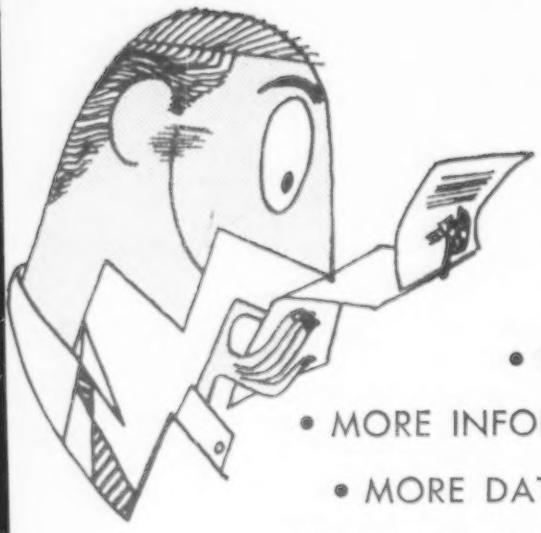

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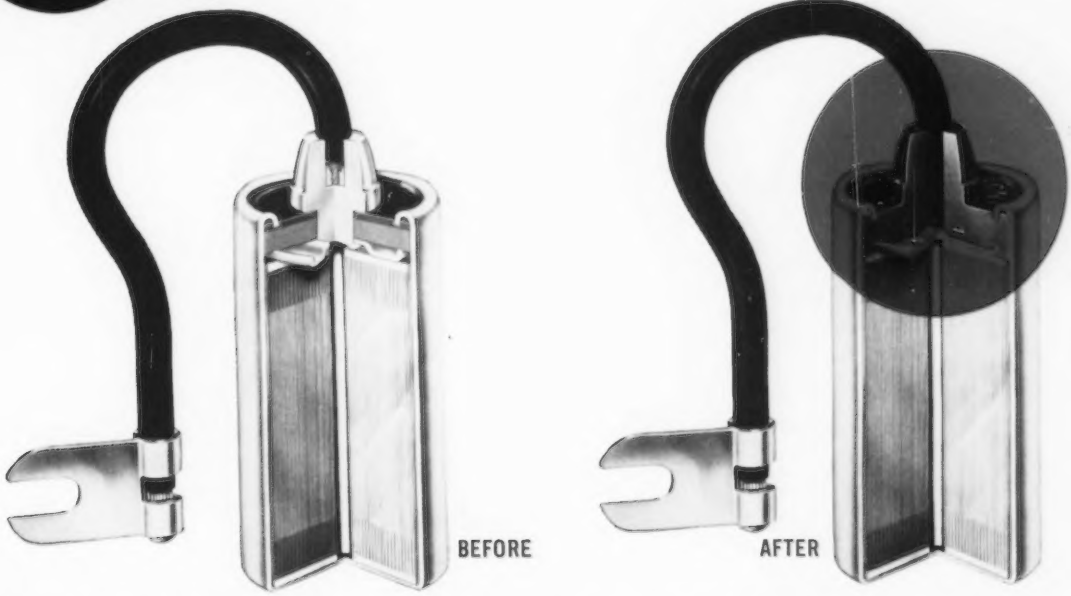
needed: *a molded condenser seal to meet 10 rigid requirements*

found: *injection-molded cap engineered by minnesota rubber*



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They took their problem to the engineers of the Minnesota Rubber Company. The Echlin designers listed 10 requirements for the condenser cover. It should have high dielectric strength, a specified durometer, an absence of moisture absorption and oil resistance.

Dimensions were to be stable and constant, and no permanent deformation after compression could be tolerated. In addition, the seal had to retain its resilience at automotive engine temperatures, be physically attractive and bear the firm's name. And, it should be capable of being produced in quantity at a reasonable price.

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The Minnesota Rubber Company, originators of modern rubber injection molding, can make similar improvements on components you may need. For full information, write to the department and address listed below. Order your 16-page brochure detailing Minnesota Rubber facilities at the same time.

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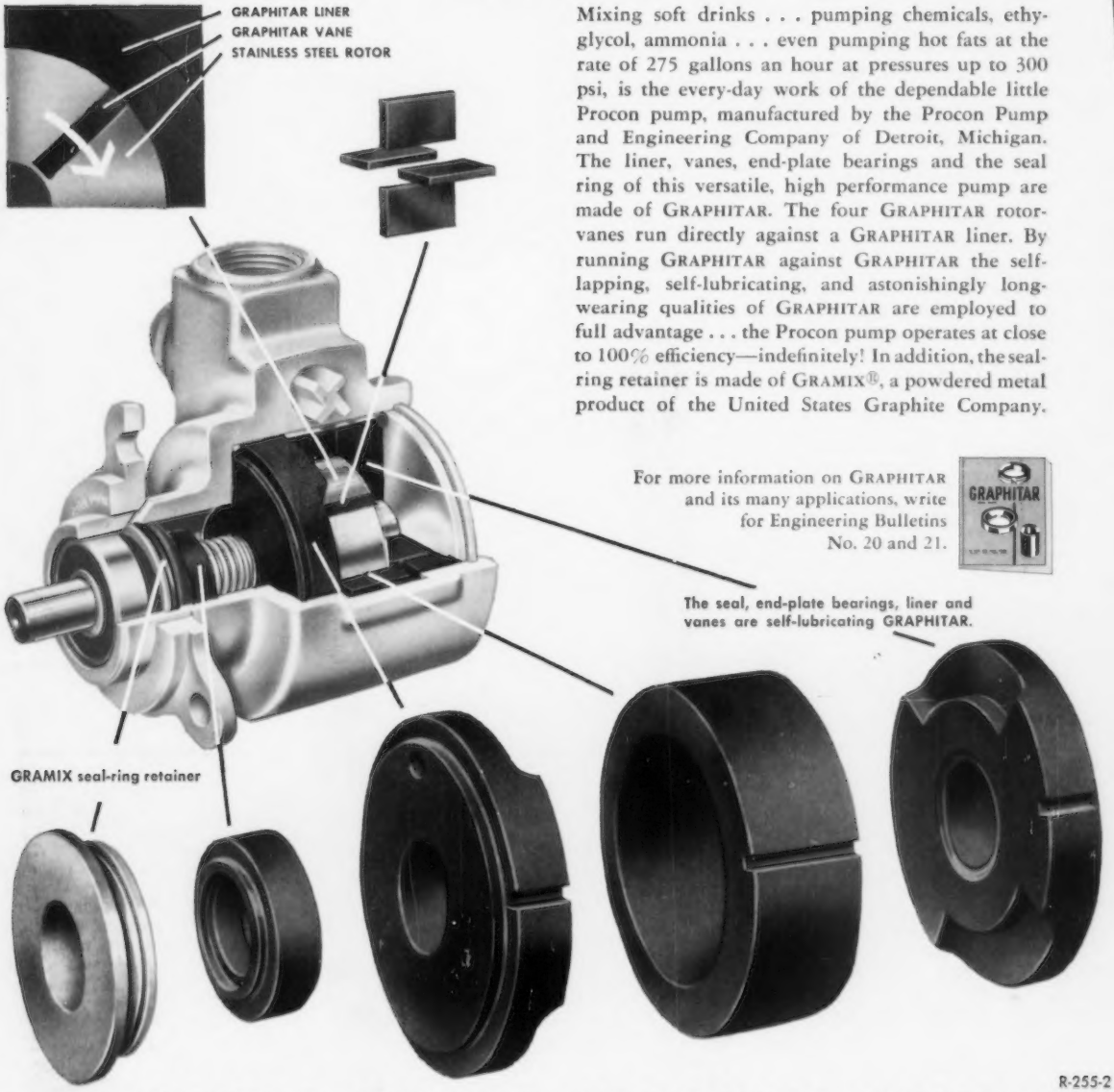
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